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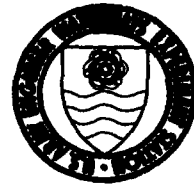
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ENGINEERING AND GEOLOGIC INVESTIGATION OF POTENTIAL SOURCES OF AGGREGATE, FORT IRWIN, CALIFORNIA

by

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P. O. Box 631, Vicksburg, Miss. 39180

August 1982

Final Report

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20. ABSTRACT (Continued).

This investigation was conducted to determine if adequate quantities of good quality fine aggregate and coarse aggregate could be excavated at a reasonable cost from two designated locations. This report describes the geology of the aggregate sources and presents the results of the field explorations and laboratory testing program.

The sites investigated were found to contain adequate quantities of good quality fine and coarse aggregates suitable for use in the planned construction activities at Fort Irwin. Excavation costs for the coarse and fine aggregate sites should be reasonable to low, respectively.

Select borrow material from both sites is suitable for use as subgrade and subbase course. Crushed material from the coarse aggregate site is suitable for use as a stabilized aggregate base with a design CBR 80. The crushed coarse aggregate material is suitable for use in bituminous concrete; however, stripping is a problem and an antistripping agent will be required. It is recommended that one percent hydrated lime be used as the antistripping agent.

Good quality portland cement concrete can be produced using aggregates from the two sites. However, since the aggregates are potentially reactive in the alkali-silica reaction, it is recommended that low-alkali portland cement be required in the concrete.

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PREFACE

The investigation reported herein was authorized by the U. S. Army Engineer District, Sacramento, Corps of Engineers, on DA Form 2544, No. SPKED-F-81-22, "Fort Irwin, California - Aggregate Exploration and Testing," dated 1 July 1981.

The field investigation was conducted during July-August 1981 by personnel of the U. S. Army Engineer Waterways Experiment Station (WES), Geotechnical Laboratory (GL), Pavement Systems Division (PSD), and Engineering Geology and Rock Mechanics Division (EG&RMD), under the general supervision of Drs. W. F. Marcuson III and P. F. Hadala, Chief and Assistant Chief of GL, respectively, and under the direct supervision of Messrs. J. W. Hall, Jr., PSD, and J. H. Shamburger, EG&RMD. The South Pacific Division Laboratory, Corps of Engineers, Sausalito, California, conducted the laboratory testing program. The WES personnel who reviewed the laboratory test results were Messrs. L. M. Smith, S. L. Webster, E. R. Brown, and A. D. Buck. This report was prepared by Messrs. Webster and Smith, who respectively wrote the engineering and geology phases of the investigation.

The Commander and Director of the WES during this investigation and the preparation of the report was COL Tilford C. Creel, CE. The Technical Director was Mr. Fred R. Brown.



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CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI)
UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
cubic yards	0.7645549	cubic metres
feet	0.3048	metres
inches	25.4	millimetres
miles (U. S. statute)	1.609344	kilometres
pounds (force) per square inch	6.894757	kilopascals
pounds (mass)	0.4535924	kilograms
pounds (mass) per cubic foot	16.01846	kilograms per cubic metre
square yards	0.8361274	square metres
tons (2000 lb, mass)	907.1847	kilograms

ENGINEERING AND GEOLOGIC
INVESTIGATION OF POTENTIAL SOURCES OF
AGGREGATE, FORT IRWIN, CALIFORNIA

PART I: INTRODUCTION

Background

1. Fort Irwin is located 40 miles north of Barstow, California. Planned construction at Fort Irwin for the National Training Center consists of a number of buildings, roads, parking areas, and other structures in the cantonment area, an airfield with structures and aprons, and a railroad spur. The total amount of bituminous and concrete aggregate required for construction ranges between 200,000 and 300,000 tons.*

Objective

2. The objective of this investigation was to determine whether an adequate quantity of good quality sand and gravel could be excavated at reasonable cost from two designated locations, FA-2 and CA-2 (Figure 1). Sufficient laboratory testing was to be conducted to determine the adequacy of the materials for use as select borrow, stabilized aggregate base course, and in bituminous and portland cement concrete.

Scope

3. The scope of the investigation involved five tasks, which were accomplished as follows:

- a. Task 1. Eight trenches were excavated at site FA-2. Test trench locations were limited to areas that had been cleared of ordnance by an Army explosive ordnance disposal (EOD) team. A backhoe was used to dig the 10-ft-deep trenches. Logs of the materials encountered were

* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 3.

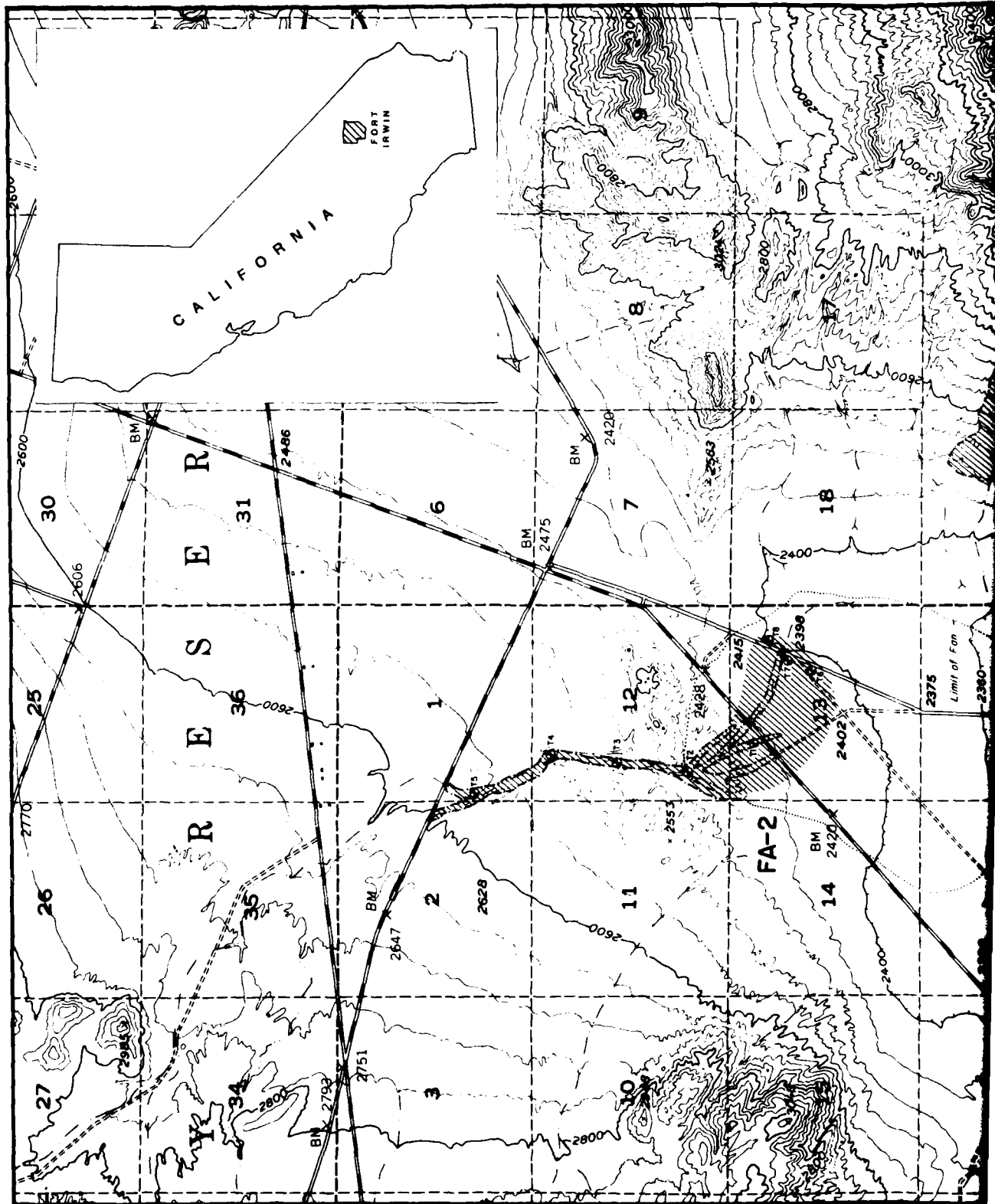


Figure 1. FA-2 and CA-2 aggregate sites, Fort Irwin

Figure 1. FA-2 and CA-2 aggregate sites, Fort Irwin, CA

constructed. Samples were taken at approximately 5-ft-depth intervals, and laboratory tests were conducted for gradation and Atterberg limits on the minus 2-1/2-in. material.

- b. Task 2. Surface materials at site CA-2 were mapped and areas containing good quality gravels were identified.
- c. Task 3. Twenty trenches were excavated by a backhoe (5- to 10-ft depths) at selected areas (determined under Task 2) at site CA-2. Materials in the trenches were logged. Samples were taken at approximate 5-ft-depth intervals, and laboratory tests were conducted for gradation and Atterberg limits on the minus 2-1/2-in. material.
- d. Task 4. Approximately 4 tons of pit-run bulk sample was obtained from each site, FA-2 (near test trench T6) and CA-2 (near test trench T2). The material from site CA-2 was sieved through a grate containing parallel bars spaced with 8-in. openings. The bulk samples were shipped to the laboratory for testing.
- e. Task 5. The bulk pit-run aggregate samples were processed and tested at the laboratory for use as select borrow materials, soil cement stabilization, stabilized aggregate base course, and bituminous and concrete mix designs.

4. This report describes the geology of the aggregate sources and presents the results of the field explorations and laboratory testing program. This report also discusses the potential of the aggregate sources for use as select borrow, soil cement stabilization, and stabilized aggregate base, and of bituminous and portland cement concrete made with these aggregates. The conclusions and recommendations made concern the development of the aggregate locations.

PART II: GEOLOGY AND FIELD EXPLORATIONS

5. The availability and value of an aggregate resource is largely a function of the geologic history of the area. Part II describes the geologic (geomorphic) conditions that strongly influence the availability and value of aggregate resources at sites FA-2 (fine aggregate) and CA-2 (coarse aggregate).

Fine Aggregate Site FA-2

Geologic setting

6. Fine aggregate site FA-2 is located in the lower reaches of a dry wash which drains an intermontane region (Bicycle Lake basin) between the Granite Mountains to the north, the Tiefort Mountains to the southeast, and an unnamed range to the west and southwest (Figure 1). Source areas within the drainage basin include Mesozoic granitic rocks, Tertiary and Quaternary volcanics, and partially cemented and unconsolidated Quaternary alluvium, colluvium, and lacustrine deposits. The Mesozoic granitic rocks are derived primarily from a low northeast-southwest trending outlier of the Granite Mountains which supply igneous (granite, diorite, granodiorite, adamellite, and tonalite), metaigneous, and small amounts of metamorphic sediments (quartzite, gneiss, and schist). The Tertiary volcanic rocks are derived from the unnamed range to the west, which provides andesite, rhyolite, dacite, and pyroclastics, a Tertiary basalt flow, and several small Pleistocene basalt plugs. The unconsolidated and semiconsolidated Quaternary deposits in the form of alluvial fans and aprons, talus cones, lacustrine terraces, valley-floor alluvium, and pediment veneers provide granitic and volcanic detritus to the wash system.

7. Sample sites are located in the lower 2.16 miles of the wash and extend from the intersection of the wash and an east-west paved road southward across Barstow Road onto the northern end of Bicycle Lake basin. The wash enters the lower reach as a wide, shallow, braided channel typical of ephemeral streams of arid regions. This character is

maintained southward through sample sites T5, T4, and T3. Between sample sites T3 and T2 the channel evolves into a more narrow (and probably more deeply entrenched) slightly sinuous channel having a distinct thalweg with a few short reaches of anastomosing channels. Just north of sample site T2 the channel passes through a gap separating a granitic outlier to the east and an erosional remnant of partially cemented Pleistocene alluvium on the west. As the channel turns to the southeast at sample site T2, it breaks up into a system of small distributary channels which flow across Barstow Road forming a broad fan that slopes gently into the northern end of Bicycle Lake basin. Sample sites T6, T7, and T8 are located on the medial portion of this fan about 0.40 miles east of Barstow Road.

8. Alluvial deposits visible in the channel bed and encountered in the sample trenches reflect their mode of deposition and the geologic history of the source area. The trenches revealed multiple sets of fining upward sequences grading upward from gravel to fine sand. The sediments occur primarily in horizontal parallel, horizontal discontinuous, lenticular, and graded planar beds in most (graveliferous) cases and low-angle and avalanche front cross-stratified beds in the finer-grained (sand) units. Volcanics (andesite, basalt, dacite, and rhyolite) comprise most of the gravel, cobbles, and boulders and are well-rounded and usually imbricated when undisturbed. The sand fraction is primarily composed of monocrystalline quartz and feldspars, and cryptocrystalline quartzite, andesite, and dacite. During brief periods of flow, discharge apparently infiltrates rapidly into the wide unconsolidated bed, reducing the ability of the stream to transport gravel and larger material. The result is a rough downstream decrease in the percentage of gravel, cobbles, and boulders and a decrease in median grain size. This rough trend may be seen from sample site T4 downstream through sites T3, T2, T1, and T7. Although the base of alluvium in the wash was encountered only once during sample trench excavation (granite was found at a depth of 7.5 ft at sample site T2), the thickness of the alluvium in the wash is probably not much greater than 10 ft. This thickness may extend to several tens of feet out on the fan (region of sample sites T6, T7, and T8).

Geologic influences
on aggregate resource

9. Four basic considerations of a potential aggregate resource that are controlled primarily by geologic conditions are: (a) gradation of material, (b) petrology (soundness), (c) volume of potential aggregate, and (d) accessibility of the resource. Gradation distributions are controlled by the energy of local geomorphic processes. Petrology is dictated by the geologic history of the source area. Volume is a function of the rate and period of geomorphic process. Accessibility is a function of the geologic history of the depositional area. In the examination of potential aggregate source locations in the FA-2 and CA-2 sites, selection of the best locations for aggregate acquisition was made based on the consideration of the spatial variability of these four considerations.

10. The unidirectional variation in rate, energy, and period of geomorphic processes combined with a general knowledge of the geologic history of the sediment source and depositional areas allows some definitive conclusions to be made regarding potential aggregate location in the FA-2 site. As mentioned previously, there is a rough downstream decrease in the percentage of coarse (gravel or larger) materials. There should also be an increase in the sorting of materials downstream, especially in interchannel areas on the downstream fan (the vicinity of sample sites T6, T7, and T8). Petrologic variability probably consists of a small increase in granitic rocks downstream of sample site T2, as the wash receives direct input of detritus from the granitic outlier on its east bank, and a decrease in friable materials (pyroclastics, or tuff) downstream due to abrasion. As the wash emerges from the constriction at sample site T2, it evolves from an environment of intermittent storage and transport of sediment (the single channel) to an environment of primarily storage, as evidenced by the distributary system of channels and a relatively broad fan of sediment. The volume of potential aggregate is greatest on this fan. The fan area is also adjacent to Barstow Road and the CA-2 site and may be readily traversed by most vehicles, optimizing accessibility.

Description of sample sites

11. At each predetermined sample site, material samples were taken at depths of 5.0 and 10.0 ft, except for site T2, where a second sample was taken at a depth of 6.5 ft. A bulk sample was taken at sample site T6. Gradational characteristics of the fine aggregate samples are given in Table 1. Sites T1 through T8 are described in the following paragraphs.

12. Sample site T1. Gravelly sand occurs throughout, with gravel increasing and sorting decreasing with depth. Median grain size also increases with depth from 1.2 to 2.0 mm (-5 to -10 ft). Sporadic (less than one percent) cobbles and boulders up to 12 in. in maximum dimension occur. Sand becomes moist at about 8.5 ft.

13. Sample site T2. Gravelly sand occurs down to a depth of 7.5 ft where basement rock was encountered. The material becomes finer with depth with a decrease in gravel (from 29 to 21 percent) and median grain size (from 1.7 to 1.5 mm). The degree of sorting increases with depth, while the amount of fines remains fairly constant. A thin gravel layer occurs at a depth of 2 ft. Sporadic cobbles up to 6 in. in maximum diameter occur also. The sand becomes moist at about 3 ft.

14. Sample site T3. Gravelly sand occurs throughout and coarsens with depth as gravel increases from 16 to 37 percent and median grain size increases from 1.3 to 2.1 mm. The sorting decreases considerably with depth, while the percentage of fines remains relatively constant. A zone of cleaner sand occurs from 7.0 to 9.2 ft. The maximum size of very sporadic cobbles is 6 in.

15. Sample site T4. Gravelly sand occurs throughout and coarsens slightly with depth as gravel increases from 40 to 42 percent and median grain size increases from 2.7 to 3.4 mm. Sorting also increases slightly with depth. Few cobbles (less than one percent) were encountered ranging in size up to 6 in.

16. Sample site T5. Two discrete units of gravelly sand overly a unit of sand with sporadic gravel. The upper unit contains a few cobbles and boulders up to 12 in. in greatest length, with 20 percent gravel and a median grain size of 1.4 mm. The second unit, from 5.5 to 8.5 ft, is

slightly finer than the upper unit, with almost no cobbles. The lower unit has only 12 percent gravel, a median grain size of 0.35 mm, and 19 percent fines. Sorting increases slightly with depth.

17. Sample site T6. Two separate units occur at site T6, the upper being sand with gravel (39 percent), poorly sorted, and having a median grain size of 2.8 mm and very sporadic cobbles and boulders up to 14 in. in maximum dimension. The lower unit, beginning at a depth of 7.4 ft, is sand with gravel (21 percent), very poorly sorted, with 13 percent fines and a median grain size of 0.62 mm. The lower unit contains no cobbles or boulders.

18. Sample site T7. Gravelly sand becomes slightly finer with depth as gravel decreases from 28 to 21 percent and median grain size decreases from 1.4 to 1.1 mm. Sorting is poor, increasing slightly with depth. Occasional cobbles and small boulders occur (less than one percent) with a maximum size of 14 in., while the percentage of fines (5 percent) remains constant.

19. Sample site T8. Site T8 is underlain by predominantly gravelly sand, coarsening with depth, but consists actually of numerous fining upward sequences of an average thickness of about 8 in. Gravel increases from 19 percent at 5 ft to 34 percent at 10 ft, while median grain size increases from 1.1 to 2.1 mm. The sorting decreases with depth as the percentage of fines (5 percent) remains constant. A few cobbles and boulders occur with a maximum size of about 14 in.

Coarse Aggregate Site CA-2

Geologic setting

20. Site CA-2 is located on an alluvial fan on the western flank of the Tiefort Mountains. The Tiefort Mountains are composed predominantly of Mesozoic rocks which include granite, adamellite, granodiorite, tonalite, diorite, and peridotite. Also occurring are sporadic metamorphic rocks (gneiss, schist, amphibolite, and metagranite). Sediments composed of these rocks and their mineralogic constituents (quartz, feldspars, amphibolite, biotite, and small amounts of accessory minerals)

have formed the apron of alluvial fans which slopes westward from the Tiefort Mountains into the northeastern quadrant of Bicycle Lake basin.

21. The alluvial fans of the Tiefort Mountains result from the accumulation of a thick wedge of coarse material at the intersection of the mountain front and the receiving basin over a period of many tens of thousands of years. As sediments were brought down steep mountain channels by various processes to the intermontane basin below, they were deposited in and adjacent to a channel which alternately occupied many different positions on the surface of the alluvial fan. While the active channel was occupying one sector of the alluvial fan, the nonactive surface of the fan was undergoing chemical and mechanical weathering from subaerial exposure. Surface weathering in arid regions such as the Fort Irwin area is usually most evident in three forms: (a) development of a dark coating or patina, known as "desert varnish," (b) granular disintegration from rock surfaces inward, and (c) spalling, or "onionskin" weathering in sheets on the surfaces of rocks. All three of these phenomena were observed on surface materials of the alluvial fans of the Tiefort Mountains.

22. The acquisition of suitable aggregate from the alluvial fan deposits of the Tiefort Mountains would be best accomplished in zones of active deposition, where the percentage of fresh, unweathered rock is of maximum occurrence. One such area is the area of CA-2 outlined in Figure 1. Coarse aggregate sample sites T1 (identified as 1 in Figure 2) through T12, T19, and T20 are in this area. Field observations reveal that surface weathering is generally minor in this region and only thinly developed on rock surfaces where it does occur.

23. Sediments contained in arid region alluvial fans are usually highly variable in particle size, degree of sorting, and geometry of depositional units. Deposits of the alluvial fan upon which the CA-2 site is located are no exception. The characteristics of the deposits of the CA-2 site are a function of the depositional processes by which they were brought to their present location. The five processes responsible for the potential aggregate at CA-2 include stream channel, sheet flow, sieve, mudflow, and debris flow deposition. The location of

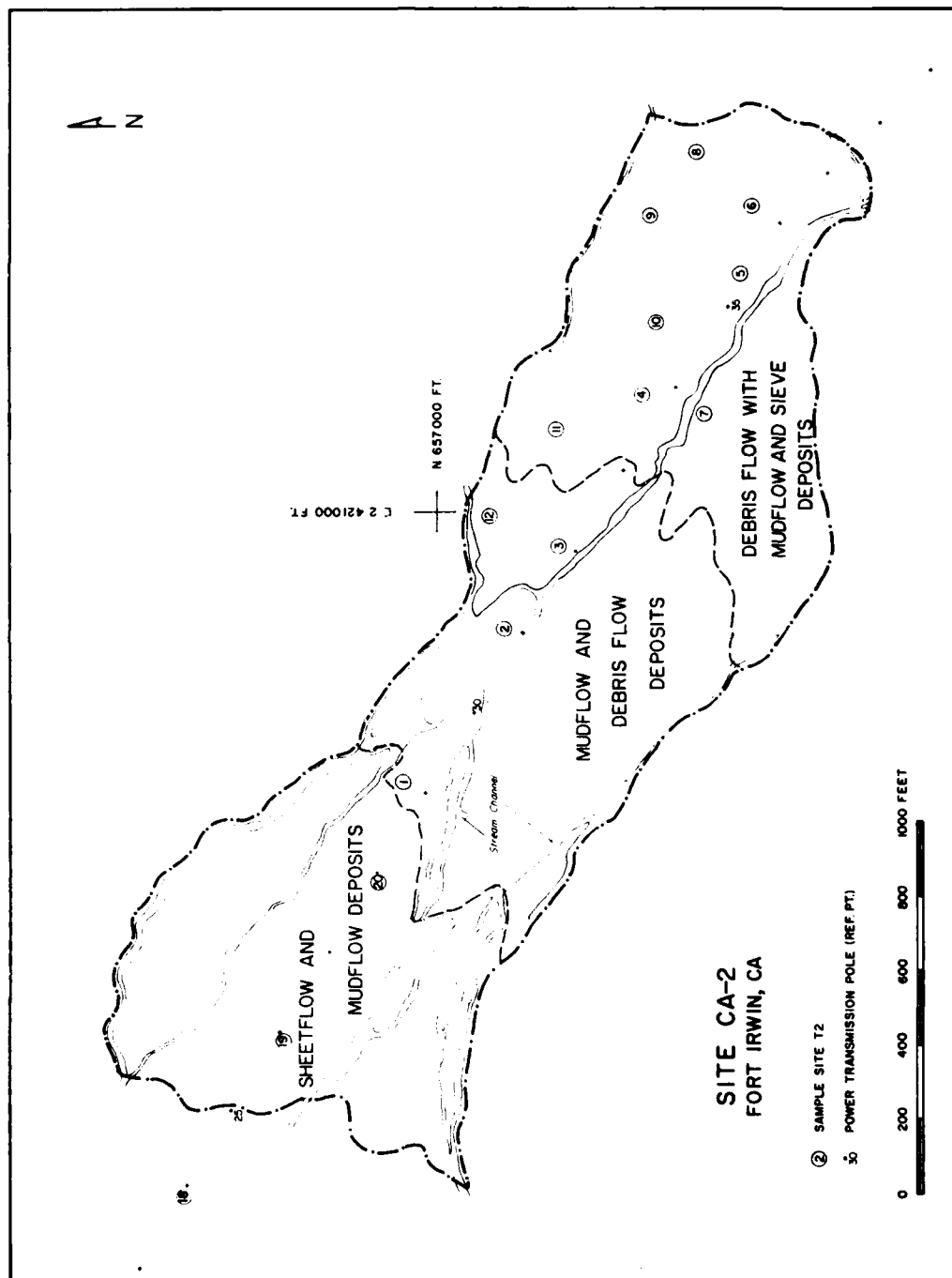


Figure 2. Coarse aggregate sample site locations

discrete deposits resulting from these five processes is a function of its relative position on the fan surface (proximal, medial, or distal) and the geomorphic history of the alluvial fan/channel/drainage basin system.

24. Stream channels extend from the upper proximal fan to the distal fan. Their deposits are usually the result of bed and bar aggradation of sand, gravel, and small cobbles during periods of moderate sediment production from the drainage basin. Stream channels decrease in size systematically down-fan as discharge is lost through infiltration into the bed to a point where the channel ends. During more infrequent high sediment production events, streamflow extends down-fan through the end of the channel and spreads out as a sheet flow on the distal fan. Sieve deposits are formed when viscous flows of mud, cobbles, and boulders flow out onto a highly permeable surface on the proximal and upper medial fan. The fines are rapidly lost through infiltration into the underlying material resulting in a relatively well-sorted lobe of cobbles and boulders at the top. Mudflows occur when sediment to water concentrations reach such a level that the flow begins to behave as a plastic mass rather than a Newtonian fluid. As they exit the drainage basin onto the fan, they spill over the channel banks and flow as lobes onto the lower proximal and medial fan surface. When sediment concentrations become very high, large boulders become entrained, buoyed by the relatively great viscosity and density of the flow. These debris flows are a result of the most infrequent (greatest magnitude) storms and may profoundly alter the surface of the alluvial fan and the location of stream channels. Table 2 summarizes the characteristics of the deposits at the CA-2 site. Figure 2 shows the general locations of the deposits on the surface of site CA-2.

Geologic influences
on aggregate resource

25. The four conditions of aggregate sources--gradation, petrology, volume, and accessibility--were considered in the determination of potential aggregate resources at the CA-2 site. Spatial variation in rate, energy, and period of geomorphic processes is more variable and

less systematic on the CA-2 site than the FA-2 site due to the more spasmodic nature of the geomorphic system responsible for its formation. However, some basic conditions permit the selection of the optimum locations for obtaining coarse aggregate. The well-defined down-fan (downslope) decrease in rock size (Table 3) is caused by the general downslope decrease in energy of sediment transport processes. Also, a general decrease in grain size with depth should occur, but this trend would only be evident in depths of several hundred feet. Petrologic variability is probably minimal with the probable exception of a relative increase in quartz and feldspar (in sand sizes) down-fan as the percentage of sand increases. Because of its conical shape, the thickness of alluvial fan deposits decreases downslope as their lateral extent increases. The surface area of site CA-2 shown in Figure 2 is approximately 253,000 sq yd, so the local thickness (which is probably at least 200 ft) is not a limiting factor in the acquisition of less than 500,000 cu yd of unprocessed aggregate. Accessibility on the CA-2 site increases downslope in terms of proximity to paved roads and surface obstacles (boulders and rough terrain).

Description of sample sites

26. In the initial determination of sample sites at CA-2, 12 sample sites were identified for excavation. Eight additional sites (T13 through T20) were added to further define the distribution of potential aggregate in the CA-2 area. Table 4 presents the size classes of the coarse aggregate for all of the CA-2 sites. Sites T1 through T12 are described in the following paragraphs.

27. Sample site T1. Desirable surface material occurs in a roughly linear deposit of boulders with cobbles. Maximum boulder size is approximately 28 in. with about 7 percent of the material being greater than 18 in. in maximum dimension. About 98 percent of the rock appears to be suitable for crushing with only minor evidence of surface weathering apparent. Particle size generally decreases with depth. A single sample was taken at 10 ft.

28. Sample site T2. Potential aggregate is contained in an elongated lobe, which is dissected by several small washes. Maximum boulder

size is approximately 24 in. with about 3 percent of the material in the greater than 18-in.-size range. The rocks are relatively unweathered (recently deposited) but are not quite as extensive in areal extent as the material at site T1. No radical change in particle-size distribution appears to a depth of 6.5 ft, where a dense, impenetrable layer of relatively large boulders was encountered. The coarse aggregate bulk sample was taken at this site.

29. Sample site T3. The material at this site was probably deposited contemporaneously with the material at site T2 and was subsequently dissected by a large wash. The surface material is slightly smaller than that at T2 with the maximum dimension of the largest boulder about 20 in. and only 2 percent of the boulders in the greater than 18-in. range. Some surficial stones exhibit a slight-to-moderate degree of weathering, but these rocks probably comprise less than 5 percent of the total. Maximum particle size decreases slightly with depth to 7 ft, where a slightly cemented boulder layer was encountered, similar to the boulder layer at site T2. A sample was taken at a depth of 5 ft.

30. Sample site T4. Potential aggregate exists as a moderately well-sorted deposit of cobbles and boulders with minimal gravel and finer materials at the surface. Maximum boulder size is about 24 in. with approximately 5 percent in the greater than 18-in. range. The occurrence of weathered rock is slightly greater than sites T1 through T3 but still less than 7 percent of the total and only moderate in degree of development. With depth, maximum particle size decreases as the percent of sand and fines increases. Samples were taken at depths of 5 and 10 ft.

31. Sample site T5. Surficial deposits consist of a wide range of particle sizes ranging from 30 in. to sand, with approximately 4 percent of the material larger than 18 in. in maximum dimension. Locally, surface weathering of the rocks may be significant, although it is usually thinly developed on most rock surfaces. The deposits are relatively homogeneous with depth except for an increase in fines. A sample was taken at a depth of 5 ft.

32. Sample site T6. Deposits at the surface are similar to those at site T5 (wide range of particle sizes) with a maximum size of 45 in.,

but only 2 percent of the total deposit is greater than 18-in. in maximum diameter. Surficial weathering of local materials is moderate. Material is relatively homogeneous with depth with a slight increase in fines with increasing depth. Samples were taken at 5- and 10-ft depths.

33. Sample site T7. This site is the only one located south of the transmission line and is located on an irregularly linear lobe of cobbles and boulders, which fall predominantly in the 4- to 18-in. range. The maximum particle size of this fairly extensive deposit is about 48 in. At the surface, about 15 percent of the material exceeds 18 in. in maximum length with only 2 percent greater than 18 in. in the subsurface. Surface weathering is minor to moderate and very thinly developed. Subsurface deposits are predominantly finer than surficial deposits with maximum sizes in the 14- to 16-in. range. A sample was taken at a depth of 5 ft.

34. Sample site T8. Surficial deposits consist of cobbles and boulders varying from 4 to 24 in. in maximum dimension. In this very poorly sorted deposit, about 6 percent of the material is in the 18- to 24-in. range. The rock surfaces appear to be fairly fresh with only minor evidence of surface weathering. Subsurface materials are considerably finer than surface deposits with only 2 percent being greater than 18 in. in maximum dimension. Samples were taken at depths of 5 and 10 ft.

35. Sample site T9. This site is relatively small, consisting of a very well-sorted deposit of cobbles and boulders in the 4- to 18-in. range. Maximum rock size is about 22 in. with 10 percent occurring in the greater than 18-in. range. Surface weathering is minimal. Subsurface material is completely different from the surface, consisting of a much more poorly sorted deposit of gravel through large boulders with much of the material less than 8 in. in maximum dimension. A sample was taken at 5 ft.

36. Sample site T10. Surficial materials at site T10 are similar to those at site T9 except they are not as well-sorted. Maximum rock size is about 38 in. with about 8 percent exceeding 18 in. in greatest length. Surface weathering is minor to slight. Rocks in the subsurface

are more poorly sorted and generally coarser, with approximately 12 percent in the greater than 18-in. range.

37. Sample site T11. The site consists of several moderately sorted linear lobes of cobbles and boulders surrounded by a very poorly sorted deposit of gravels to large boulders. Maximum rock size is about 40 in. with approximately 6 percent exceeding 18 in. Surface weathering is minor to slight. Subsurface material is considerably finer with most of the deposit in rocks smaller than 4 in. A second sequence of coarsening upward material may be seen at the base of the trench. A sample was taken at a depth of 5 ft.

38. Sample site T12. Potential aggregate occurs in poorly sorted irregularly linear lobes of cobbles and boulders, which vary in size from 4 to 24 in. This site has generally smaller size materials than the preceding locations with only about 1 percent of the rock exceeding the 18 in. in maximum dimension. Surface weathering is minor to slight. Materials in the subsurface are not substantially different from those at the surface except for the increase in fines. A sample was taken at a depth of 5 ft.

39. Coarse aggregate sample sites T13 through T20 described below are located downslope of the optimum coarse aggregate region at the CA-2 site. They were excavated, and in some cases sampled, in order to provide maximum information for the contractor in locating optimum aggregate sources. They were not included in the list of primary sample sites to be excavated at CA-2.

- a. Site T13. Gravel and cobbles occur as stringers in a silty sand matrix, becoming slightly cemented at the base of the trench. No sample was taken.
- b. Site T14. The site consists of gravel with a few cobbles in a silty sand matrix, becoming slightly cemented at -6 ft. No sample was taken.
- c. Site T15. Gravel with cobbles occur in a silty sand matrix at this site, with an increase in coarse materials with depth. Gravel and cobbles are found throughout, not as stringers. Maximum diameter is about 6 in. No samples were taken.
- d. Site T16. The excavated section consists of cobbles with boulders in a silty sand matrix with sporadic lenses of

gravel in silty sand. Occasional boulders noted up to 30 in. No samples were taken.

- e. Site T17. The site consists of cobbles with a few boulders in a silty sand matrix. Samples were taken at depths of 5 and 10 ft.
- f. Site T18. Cobbles with a few boulders occur in a silty sand matrix. Larger cobbles and boulders are found in several layers, two rocks thick above lenses of better sorted gravel and sand. No samples were taken.
- g. Site T19. The excavated section consists of cobbles with a few boulders in silty sand, occurring very generally in horizontal layers. At 7.5 ft, the material becomes finer (mostly gravel with sand), packed, and slightly cemented. No samples were taken.
- h. Site T20. Cobbles with a few boulders occur in silty sand. At about 6 ft, the material becomes slightly cemented, oxidized, and slightly better sorted in small cobbles and gravel in sand. Samples were taken at depths of 5 and 10 ft.

PART III: DISCUSSION OF LABORATORY TEST RESULTS

40. The results of the laboratory testing program conducted by the South Pacific Division Laboratory are presented in Appendix A. A discussion of the laboratory test results describing the potential of the aggregate sources follows.

Select Borrow

41. The minus 3-in. material from both FA-2 and CA-2 sites is suitable for use as subgrade and subbase course. Material from site FA-2 is suitable as subbase material with a design California Bearing Ratio (CBR) 40 when compacted to 100 percent of the CE-55 compaction effort. The minus 3-in. material from site CA-2 is suitable as subbase material with a design CBR 50, the maximum design CBR that can be assigned to a subbase material, as described in TM 5-824-2/AFM 88-6, Chap. 2 and 5-822-5/AFM 88-7, Chap. 3 (Headquarters, Dept. of the Army and the Air Force, 1969 and 1971) and TM 5-823-2 (Headquarters, Dept. of the Army, 1958). Based on bulk sample information, less than 4 percent of the material at site FA-2 is larger than a 3-in. sieve size, while over 50 percent of the material at site CA-2 is larger than a 3-in. sieve size. Site FA-2 is more accessible than CA-2; however, material from site CA-2 would require less water for compaction. Optimum water content is 6.5 percent for CA-2 material and 10.5 percent for FA-2 material. Laboratory CBR values were significantly higher for the CA-2 material.

42. The minus 3-in. select borrow material from site CA-2 would be suitable for base course beneath rigid pavements when compacted to the requirements of TM 5-824-3/AFM 88-6, Chap. 3 (Headquarters, Dept. of the Army and the Air Force, 1970).

Soil Cement Stabilization

43. Based on the soil cement laboratory data on site FA-2 material, a cement content of approximately 5 percent (by weight) would be

required to meet the 7-day compressive strength of at least 250 psi for use as a subbase for flexible or rigid pavements, as specified in TM 5-822-4/AFM 88-7, Chap. 4 (Headquarters, Dept. of the Army and the Air Force, 1982). Since material from site FA-2 is already suitable as subbase with a design CBR 40 when compacted to 100 percent of the CE 55 compaction effort, it is doubtful that additional benefits obtained by cement stabilization would be economical for the FA-2 material. However, if cement stabilization is used, the procedures contained in TM 5-822-4/AFM 88-7, Chap. 4, should be followed for determining the design cement content and moisture-density relations of the soil-cement mixture.

Stabilized Aggregate Base Course

44. Based on the laboratory abrasion, Atterberg limits, gradation, compaction, and soaked CBR test data, the aggregate from site CA-2 is suitable for use as a stabilized aggregate base with a design CBR 80 (TM 5-823-2 and TM 5-824-2/AFM 88-6, Chap. 2). Compaction requirements should be at least 100 percent of the CE 55 compaction effort. The 1-1/2-in. maximum size, crushed, graded sandy gravel from site CA-2, which was used as the stabilized aggregate base course, was nonplastic and had an optimum moisture content of 6 percent for the CE 55 compaction effort. Soaked laboratory CBR values ranged from 140 to 240 when this material was compacted at 100 percent of CE 55 between a moisture content range of 4.5 to 7.5 percent, which could be expected during field construction. The laboratory CBR values are probably higher than those that can be expected in the field because of the confinement effects of the compaction mold. Although laboratory data regarding aggregate shape and percent of fractured faces were not reported for the material tested, these data can be controlled during production crushing to meet the specification requirements in CE-807.03 (Dept. of the Army, OCE, 1972a).

Bituminous Concrete

45. Table 10 of the laboratory report (Appendix A) presents a summary of the asphalt concrete mix design data. The percent retained stability does not meet the specifications required by CE-807.22 (Dept. of the Army, OCE, 1972b). For the 500-pound Marshall stability mix design, the percent retained stability was 55 and the minimum specification was 75. For the 1800-pound Marshall stability mix design, the percent retained stability was 45 and the minimum specification was 75. Therefore, an antistripping agent should be added and the mix design run again. It is recommended that 1 percent hydrated lime be used as the antistrip agent. For plant production the lime could be sprayed on the aggregate as a slurry.

Portland Cement Concrete

46. The following is a summary comparing the concrete test specifications with laboratory test results (Appendix A). These concrete specifications (CRD-C) are described in the Handbook for Concrete and Cement (WES, 1981).

a. Gradation of Aggregate.

Coarse aggregate. (Spec. ASTM C 33 (1978a))

<u>Sieve Size</u>	<u>Percent Passing</u>			
	<u>Spec. No. 4-3/4</u>	<u>CA-2 Pit Run</u>	<u>CA-2 Crushed</u>	<u>Combined 33 Percent Crushed 67 Percent Pit Run</u>
2 in.	--	--	--	--
1-1/2 in.	--	--	--	--
1 in.	100	100	100	--
3/4 in.	90 - 100	100	100	100
1/2 in.	--	67.3	60.8	64.6
3/8 in.	20 - 55	50.0	34.7	45.0
No. 4	0 - 10	--	--	--
No. 8	0 - 5	--	--	--

Fine aggregate. (Spec. ASTM C 33)

<u>Sieve Size</u>	<u>Spec.</u>	<u>FA-2 Pit Run</u>	<u>CA-2 Crushed</u>	<u>Pit Run Plus 5.5 Percent Crushed</u>
3/8 in.	100	100	100	100
No. 4	97 + 3	100	100	100
No. 8	85 + 5	82	65	81
No. 16	70 + 10	57	43	56
No. 30	45 + 15	35	26	35
No. 50	20 + 10	19	22	19
No. 100	6 + 4	6	17	7
FM	2.40 to 2.90	3.01	3.27	3.02

b. Organic Impurities.

	<u>Spec. CRD-C 12</u>	<u>Test Results</u>
On sand FA-2	Clear	Clear

c. Abrasion Tests.

	<u>Spec. ASTM C 33</u>	<u>Test Results</u>
Coarse aggregate CA-2	50 percent, maximum	29 percent 24 percent

d. M SO₄ Soundness

	<u>Spec. ASTM C 33</u>	<u>Test Results</u>
Coarse aggregate CA-2	18 percent, maximum	3.3 percent
	<u>Spec. CRD-C 133</u>	<u>Test Results</u>
Fine aggregate CA-2	15 percent, maximum	8.5 percent
Fine aggregate FA-2	15 percent, maximum	17.1 percent

e. Soft Particles.

	<u>Spec. CEGS-02611 (6.1.5)</u> (Dept. of the Army, OCE, 1975)	<u>Test Results</u>
Coarse aggregate CA-2 (1-1/2-in.-No. 4)	Airfield pavement 2 percent maximum	1.3 percent

	<u>Spec. CEGS-02611 (6.2.4)</u>	<u>Test Results</u>
Fine aggregate FA-2 (minus No. 4)	Clay lumps and friable part. 1.0 percent	1.3 percent
	- No. 200 material 3.0 percent	2.6 percent
	Total all deleterious 3.0 percent	3.9 percent

f. Quick Chemical.

	<u>Spec. CRD-C 128 (Table 2)</u>	<u>Test Results</u>
Coarse aggregate CA-2	All 3 points lie on innocuous side of curve	All 3 points lie on in- nocuous side of curve
Fine aggregate CA-2		
Fine aggregate FA-2		

g. Shape of Coarse Aggregate.

<u>Spec. CEGS-02611 (6.1.3)</u>	<u>Test Results</u>
20 percent maximum flat or elongated particles. Generally be spherical or cubical	--

h. Shape of Fine Aggregate.

<u>Spec. CEGS-02611 (6.2.2)</u>	<u>Test Results</u>
Generally spherical or cubical shape particles	--

i. Petrographic Examination.

<u>Spec. CEGS-02611</u>	<u>Test Results</u>
Coarse aggregate (6.1.5)	--
Fine aggregate (6.2.4)	--

j. Mortar Cube Strength.

<u>Spec. CRD-C 116</u>	<u>Test Results</u>
CA-2 sand	7 days = 1.7 28 days = 1.5
FA-2 sand	7 days = 2.0 28 days = 1.9
	(Ratio of sand to OTTAWA sand)

k. Mortar Bar.

<u>Spec. CRD-C 123</u>	<u>Test Results</u>
Alkali-silica reactive if expansion > 0.10 at 6 mo. or expansion > 0.05 at 3 mo.	Alkali-silica reactive (based on phone call to Paul Hetch on 1-7-82)

l. Drying Shrinkage.

<u>Spec. CRD-C 25</u>	<u>Test Results</u>
	--

47. The gradation requirements can be adjusted in the field to meet the specifications.

48. The $M SO_4$ soundness test on the fine aggregate from FA-2 did not meet the specification; however, this test is not important when the total concrete aggregate mix (coarse plus fine aggregate) is considered.

49. The mortar bar test showed the Fort Irwin aggregate to be potentially reactive in the alkali-silica reaction. Therefore, protective measures should be used. The use of low-alkali portland cement should be required. If that requirement is not possible, then an effective pozzolan as described in ASTM C 441 (1978b) should be used.

50. A review of the gradations of the FA-2 test pit materials indicated that test pit sites T7 and T8 offered the best potential for the fine aggregate source. In general, the material at these sites will meet the ASTM C 33 (1978a) fine aggregate specifications when the + No. 4 material is removed and some or all of the - No. 200 material is removed.

51. A review of the gradations of the CA-2 test pit materials (Tables 3 and 4) shows that coarse aggregate potential with rocks greater than a 4-in. size ranges from 0 percent at downslope sample site T14 to only 22 percent at T20. Material in this area is basically a silty sand containing cobbles with a few boulders. Development of coarse aggregate material downslope from sample site T20 would be expensive because of the low percentage of desirable aggregates available. However, the development at sample site T1 and proceeding upslope to T8, an average of 58 percent of the material is greater than 4 in. Also, since only about 4 percent of the material between T1 and T8 is larger than 18 in., this material could be excavated and processed at a reasonable cost. Since most sample sites were located north of the power transmission line, development at the coarse aggregate site in this area would be recommended.

52. Parts or all of the following aggregate test results were not included in the laboratory report (Appendix A).

- a. Shape of Coarse Aggregate, CRD-C 119.
- b. Shape of Fine Aggregate, CRD-C 120.
- c. Petrographic Examination, CRD-C 127.
- d. Mortar Bar, CRD-C 123.
- e. Drying Shrinkage, CRD-C 25.

PART IV: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

53. Based on the field explorations conducted, the geology of the aggregate sources, and the results of the laboratory tests conducted, the following conclusions are made.

- a. The aggregate sites designated as FA-2 and CA-2 (Figure 1) contain adequate quantities of good quality sand and gravel suitable for use in the planned construction activities at Fort Irwin. The fine aggregate site FA-2 is readily accessible by paved road, and excavation costs should be low. Excavation costs for the coarse aggregate site CA-2 should be reasonable; however, construction of an access road to the site would be required.
- b. The minus 3-in. select borrow material from both FA-2 and CA-2 sites is suitable for use as the subgrade and sub-base course.
- c. A cement content of 8 percent (by weight) would be required to obtain a 7-day compressive strength of 400 psi for the FA-2 material.
- d. Crushed aggregate from site CA-2 is suitable for use as a stabilized aggregate base with a design CBR 80.
- e. Aggregate from site CA-2 is suitable for use in bituminous concrete; however, stripping is a problem with the Fort Irwin aggregates. An antistripping agent will be required.
- f. Good quality portland cement concrete can be produced using aggregates from both CA-2 and FA-2 sites; however, the aggregates are potentially reactive in the alkali-silica reaction and protective measures should be used.

Recommendations

54. It is recommended that:

- a. Fine aggregate site FA-2 be developed in the vicinity of sample sites locations T7 and T8 (Figure 1). Material at these locations would require the least processing to meet the fine aggregate specifications for portland cement concrete.

- b. Development at the coarse aggregate site CA-2 (Figure 2) be started near sample site T1 and proceed uphill, keeping north of the power transmission line.
- c. An antistripping agent be added and the bituminous mix design run again. One percent hydrated lime be used as the antistrip agent. For plant production the lime could be sprayed on the aggregate as a slurry.
- d. Low-alkali portland cement be required in the concrete. If that requirement is not possible, then an effective pozzolan as described in ASTM C 441 should be used.

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CRD-C 12-79 Standard Method of Testing Air-Entraining Admixtures for Concrete

CRD-C 25-76 Standard Recommended Practice for Examination and Sampling of Hardened Concrete in Constructions

CRD-C 116-70 Standard Method of Test for Effect of Organic Impurities in Fine Aggregate on Strength of Mortar

- CRD-C 123-72 Standard Method of Test for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)
- CRD-C 128-72 Standard Method of Test for Potential Reactivity of Aggregates (Chemical Method)
- CRD-C 133-81 Standard Specification for Concrete Aggregates

Table 1

Ft. Irwin Fine Aggregate

(Percent Retained on Each Sieve)

	T1		T2		T3		T4		T5		T6		T7		T8	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
+2½"	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
2"	0	4	1	0	0	3	0	0	0	0	5	0	2	0	0	3
1½"	1	1	3	3	2	3	2	3	6	1	1	4	3	2	1	1
1"	0	3	2	3	3	5	5	5	2	1	4	1	2	3	1	4
¾"	1	3	2	2	1	3	7	3	1	1	4	2	4	1	1	4
½"	1	5	4	2	2	5	10	8	2	1	7	3	3	4	3	3
⅜"	2	5	4	3	2	5	6	7	2	3	6	2	4	2	3	3
No. 4	9	10	13	8	6	13	12	18	7	5	17	4	12	7	10	10
No. 8	15	15	14	15	15	12	13	18	14	5	15	6	13	11	12	14
No. 16	23	19	15	20	21	12	19	16	21	6	15	10	10	16	16	15
No. 30	21	16	14	18	22	13	15	11	18	10	14	15	15	18	19	12
No. 50	13	10	11	11	15	11	6	5	11	22	8	17	18	18	18	10
No. 100	6	4	6	3	5	7	3	3	5	22	3	12	8	7	9	6
No. 200	2	1	2	2	2	3	1	1	3	4	1	6	3	4	2	4
PAN	6	4	9	10	4	5	3	4	8	19	5	13	5	5	5	5
% Gravel	14	31	29	21	16	37	40	42	20	12	39	21	28	21	19	34
% Sand	80	65	62	69	80	58	57	54	72	69	56	66	67	74	76	61
% Silt																
or Clay	6	4	9	10	4	5	3	4	8	19	5	13	5	5	5	5
D ₅₀ (mm)	1.2	2.0	1.7	1.5	1.3	2.1	2.7	3.4	1.4	0.35	2.8	0.62	1.4	1.1	1.1	2.1
S ₀	2.26	3.08	3.46	2.67	2.31	4.01	3.19	2.63	2.67	2.43	3.06	3.69	3.78	2.97	2.77	3.87

Note: Two samples were taken at each site. Sample 1 was taken at 5 ft and sample 2 at 10 ft.

Table 2
Characteristics of Deposits, Coarse Aggregate Site CA-2

Depositional Process	Largest Sediments	Smallest Sediments	Sorting	Deposit Thickness	Percent of		Location* On Fan	Value as Aggregate Resource
					Surface Area			
Stream channel	Cobbles	Fine sand	Moderate to very good	2-20 ft	1.5		Proximal to distal	Generally very good, but locally limited in volume
Sheet flow	Gravel	Silt	Moderate to good	0.1-1.0 ft	12		Distal	Fair for fine aggregate, poor for coarse
Sieve	Cobbles to boulders	Cobbles	Very good	2-5 ft	0.5		Proximal	Excellent, but locally limited in volume
Mudflow	Cobbles	Silt	Very poor	1-6 ft	18		Medial and distal	Fair to poor, fines often excessive
Debris flow	Boulders	Silt	Very poor	3-30 ft	68		Proximal and medial	Fair, but may be poor when boulders too large

* Proximal is the upper fan; medial, the mid-fan; and distal, the lower fan.

Table 3

Downslope Variability of Rock Sizes, Site CA-2

<u>Sample Site</u>	<u>Maximum Diameter, in.</u>	<u>Percent >18 in.</u>	<u>Percent >8 in.</u>	<u>Percent >4 in.</u>	<u>Percent <4 in.</u>
T8	24	4	44	69	31
T6	45	2	12	32	68
T5	30	4	34	69	31
T4	24	5	13	48	52
T3	20	2	32	67	33
T2	24	3	43	68	32
T1	28	3.5	38.5	57.5	42.5
T20	24	3	9	22	78
T19	26	2	3	15	85
T18	18	0	4	13	87
T17	14	0	3	11	89
T16	30	3	18	30	70
T15	6	0	0	2	98
T14	4	0	0	0	100
T13	4	0	0	0	100

Note: Sample sites are listed in order from upslope (T8) to downslope (T13). Sample sites T7, T9, T10, T11, and T12 are not listed because they are in redundant slope positions.

Table 4

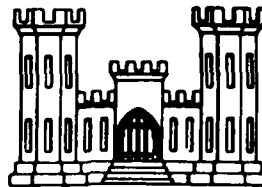
Size Classes of Aggregate at CA-2 Sample Sites

<u>Trench</u>	<u>Maximum in.</u>	<u>Percent >18 in.</u>	<u>Percent 8 → 18 in.</u>	<u>Percent 4 → 8 in.</u>	<u>Percent <4 in.</u>
T1 (0 → 5')	28	7	60	18	15
(5 → 10')		0	10	20	70
T2 (0 → 10')	24	3	40	25	32
T3 (0 → 10')	20	2	30	35	33
T4 (0 → 10')	24	5	8	35	52
T5 (0 → 10')	30	4	30	35	31
T6 (0 → 10')	45	2	10	20	68
T7 (Surface)	48	15	55	28	2
(1 → 10')		2	8	10	80
T8 (Surface)	24	6	68	16	10
(1 → 10')		2	12	34	52
T9 (Surface)	22	10	40	45	5
(1 → 10')		10	12	18	60
T10 (Surface)	38	8	15	60	17
(1 → 10')		12	30	28	30
T11 (Surface)	40	6	40	28	26
(1 → 10')		0	2	6	92
T12 (0 → 10')	24	1	6	30	63
T13	4	0	0	0	100
T14	4	0	0	0	100
T15	6	0	0	2	98
T16	30	3	15	12	70
T17	14	0	3	8	89
T18	18	0	4	9	87
T19	26	2	1	12	85
T20	24	3	6	13	78

APPENDIX A: LABORATORY REPORT

A1/A2

**DEPARTMENT OF THE ARMY
SOUTH PACIFIC DIVISION, CORPS OF ENGINEERS
LABORATORY**



REPORT
OF
AGGREGATE TESTS

FORT IRWIN, CALIFORNIA

AGGREGATE QUALITY TESTS
ON BASE SOURCES

NOVEMBER 1981

SAUSALITO, CALIFORNIA

A3 /A4

FORT IRWIN
CALIFORNIA

AGGREGATE QUALITY TESTS
ON BASE SOURCES

NOVEMBER 1981

AUTHORIZATION

1. The work reported herein was requested by DA Form 2544, No. WES-81-81, dated 24 July 1981, from the Waterways Experimental Station.

PURPOSE AND SCOPE

2. The purpose of this study was to determine the quality of the submitted aggregates for potential use in concrete, bituminous pavement, soil cement, select borrow and base coarse.

SAMPLES

3. On 2 August 1981, the following samples were received:
 - a. Coarse Aggregate - 4 tons, from Powerline Wash-Pit Run, identified as CA-2.
 - b. Fine aggregate - 4 tons, from Battalion Hill-Pit Run, identified as FA-2.
 - c. Fine aggregate - trench samples - 16 sacks - 16 samples.
 - d. Coarse aggregate - trench samples - 56 sacks - 18 samples.

TEST METHODS

4. The pit run coarse aggregate samples were processed, separated into individual sizes, and all +2-inch rock was crushed. Most of the pit run fine aggregate sample was separated in +No. 4 and - No. 4 material. Tests were made as follows:

- a. Aggregate

- (1) Gradation of Aggr., CRD-C-103
- (2) Organic Impurities, CRD-C-121
- (3) Sp. Gr. & Absorption, CRD-C-107 & 108
- (4) Abrasion Tests, CRD-C-117

- (5) Mg SO₄ Soundness, CRD-C-117
- (6) Soft Particles, CRD-C-130
- (7) Quick Chemical, CRD-C-128
- (8) Shape of Coarse Aggregate, CRD-C-119
- (9) Shape of Fine Aggregate, CRD-C-120
- (10) Petrographic Examination, CRD-C-127
- (11) Mortar Cube Strength, CRD-C-116
- (12) Mortar Bar, CRD-C-123
- (13) Drying Shrinkage, CRD-C-25

b. Concrete

- (1) Selecting Mix Proportions, CRD-C-3
- (2) Making and Curing Concrete Specimens, CRD-C-10
- (3) Air Content of Freshly Mixed Concrete, CRD-C-41
- (4) Slump Test, CRD-C-5
- (5) Compressive Strength of Cylinders CRD-C-14
- (6) Flexural Strength, CRD-C-16

c. Bituminous, MIL-STD-620A

d. Soil

(1) Grain-size Analysis, Atterberg Limits and Specific Gravity. Testing methods conformed to the procedures described in Engineer Manual, EM-1110-2-1906, "Laboratory Soil Testing", 30 November 1970.

(2) Classification The soil was classified in accordance with "The Unified Soil Classification System", TM No. 3-357, Appendix A, April 1960.

(3) California Bearing Ratio. Test methods conformed to procedures described in MIL-STD-621A, Method 101.

(4) Compressive Strength. The specimens were molded to approximately 95% maximum density in general accordance with ASTM Designation D 1632-63, except that they were formed in a 2.8-inch diameter by 6.4-inch high cylinder and were removed from the cylinder immediately after compaction. Compressive strengths were determined in accordance with ASTM Designation D 1633-63. All specimens were capped before compression.

TABLES, FORMS AND PLATE

5. The following summary and data sheets are included with this report:

- | | |
|------------------|---------------------------------|
| a. SPD Forms 47 | Physical Test of Aggregates |
| b. Table 1 | Gradation of Concrete Aggregate |
| c. Table 2 - 5 | Gradation of Trench Samples |
| d. WES Forms 477 | Sulfate Soundness |
| e. Table 6 & 7 | Petrography |

f. WES Form 896
g. Table 8 & 9
h. WES Forms 553
i. Table 10
j. WES Form 886
k. SPD Forms 158
l. Plate 1
m. Table 11
n. SPD Form 97
o. SPD Form 165
p. ENG Form 2007
q. SPD Form 97
r. SPD Form 165
s. ENG Form 2087

Quick Chemical Test
Summary Concrete Mix Design
Mix Design Sheets
Summary Asphalt Design
Grading of Asphalt Aggretate
Asphalt Design
Soil Cement Strength
Soil Cement - FA-2
CBR, FA-2
CBR, FA-2, Summary
Gradation Curve, CBR, FA-2
CBR, CA-2
CBR, CA-2, Summary
Gradation Curve, CBR, CA-2

REPORT OF PHYSICAL TESTS OF CONCRETE AGGREGATE

SPD FORM 47
OCT 74

A8

CORPS OF ENGINEERS, U.S. ARMY
SOUTH PACIFIC DIVISION LABORATORY
SAUSALITO, CALIFORNIA

REPORT OF PHYSICAL TESTS OF CONCRETE AGGREGATE

PROJECT FORT IRWIN	DATE November 1981
DISTRICT	CONTRACT NO.
SPECIFICATION	
SAND SOURCE Fine Aggregate	DATE RECEIVED
COARSE AGGREGATE SOURCE Fine Aggregate	LABORATORY NO.

SIEVE ANALYSES, CUMULATIVE % PASSING

SIEVE SIZE	3/4" - 1-1/2"		1-1/2" - 2-1/2"		COARSE AGGREGATE COMBINED IN MIX
	GRADING	SPECIFIED	GRADING	SPECIFIED	
2-1/2"	As Received				
2"	96				
1-1/2"	94				
1"	92				
3/4"	89				
1/2"	85				
3/8"	81				
NO. 4	71				
NO. 8	See Sand				

SIEVE SIZE	NO. 4 - 1"		1" - 2"		SIEVE SIZE	SAND	
	GRADING	SPECIFIED	GRADING	SPECIFIED		GRADING	
2-1/2"					3/8"	As Received	Scalped
2"					NO. 4	71	100
1-1/2"					NO. 8	58	82
1"					NO. 16	41	57
1/2"					NO. 30	25	35
NO. 4					NO. 50	14	19
NO. 8					NO. 100	4	6
					FM		3.01

<p align="center">MORTAR STRENGTH</p> <p>RATIO OF SAMPLE TO OTTAWA SAND 7-DAYS <u>2.0</u> 28-DAYS <u>1.9</u></p> <p>TEST METHOD:</p>		<p align="center">SPECIFIC GRAVITY AND ABSORPTION</p> <table border="1"> <tr> <th>SIZE</th><th>DULK SP. GR.</th><th>% ABSORPTION</th></tr> <tr> <td>SAND</td><td>2.44</td><td>4.4</td></tr> <tr> <td>NO. 4 - 3/4"</td><td></td><td></td></tr> <tr> <td>3/4" - 1-1/2"</td><td></td><td></td></tr> <tr> <td>1-1/2" - 2-1/2"</td><td></td><td></td></tr> <tr> <td>NO. 4 - 1"</td><td></td><td></td></tr> <tr> <td>1" - 2"</td><td></td><td></td></tr> </table> <p>TEST METHOD:</p>		SIZE	DULK SP. GR.	% ABSORPTION	SAND	2.44	4.4	NO. 4 - 3/4"			3/4" - 1-1/2"			1-1/2" - 2-1/2"			NO. 4 - 1"			1" - 2"		
SIZE	DULK SP. GR.	% ABSORPTION																						
SAND	2.44	4.4																						
NO. 4 - 3/4"																								
3/4" - 1-1/2"																								
1-1/2" - 2-1/2"																								
NO. 4 - 1"																								
1" - 2"																								
<p align="center">DECANTATION</p> <p>% PASSING NO. 200 SIEVE Received <u>1.9</u> Scalped <u>2.6</u></p> <p>TEST METHOD:</p>		<p align="center">LOS ANGELES ABRASION TEST</p> <table border="1"> <tr> <td>CLASS</td><td></td><td></td></tr> <tr> <td>NO. REVOLUTIONS</td><td>100</td><td>500</td></tr> <tr> <td>WT. LOSS IN PERCENT</td><td></td><td></td></tr> </table> <p>TEST METHOD:</p>		CLASS			NO. REVOLUTIONS	100	500	WT. LOSS IN PERCENT														
CLASS																								
NO. REVOLUTIONS	100	500																						
WT. LOSS IN PERCENT																								
<p align="center">ORGANIC IMPURITIES</p> <p>(COLORIMETRIC TEST) <u>Clear</u></p> <p>TEST METHOD:</p>																								

SPD FORM 47
1 OCT 74

EDITION OF 18 FEB 55 WILL BE USED UNTIL EXHAUSTED

TABLE 1

FORT IRWIN

GRADATIONS

CUMULATIVE PERCENT PASSING

Sieve Size	<u>PIT RUN</u>		<u>CRUSHED</u>
	<u>Coarse Aggregate Source</u>	<u>Fine Aggregate Source</u>	<u>Over 2" from Coarse Aggregate Source</u>
2 " (max 12")	68	96	100
1½"	59	94	95
1"	51	92	80
¾"	45	89	70
½"	40	85	52
⅜"	38	81	40
No. 4	30	71	24
No. 8	26	58	16
No. 16	21	41	11
No. 30	16	25	7
No. 50	12	14	6
No. 100	8	4	3
No. 200	4.4	1.9	1

TABLE 2

PORT IRWIN
SACK GRADATION
SURVEY

CUMULATIVE PERCENT PASSING
FINE AGGREGATE

<u>Sieve Size</u>	<u>T6-1</u>	<u>T6-2</u>	<u>T7-1</u>	<u>T7-2</u>	<u>T8-1</u>	<u>T8-2</u>
3	100	100	100	100	100	100
+ 2½	100	100	100	100	100	94
2	100	95	100	98	100	91
1½	99	91	97	96	99	90
1	95	90	95	93	98	86
¾	91	88	91	92	97	82
1/2	84	85	88	88	94	79
3/8	78	83	84	86	91	76
No. 4	61	79	72	79	81	66
No. 8	46	73	59	68	69	52
No. 16	31	63	49	52	53	37
No. 30	17	48	34	34	34	25
No. 50	9	31	16	16	16	15
No. 100	6	19	8	9	7	9
No. 200	5	13	5	5	5	5

TABLE 3

FORT IRWIN
SACK GRADATION
SURVEY

CUMULATIVE PERCENT PASSING
FINE AGGREGATE

Sieve Size	T-1	T1-2	T2-1	T2-2	T3-1	T3-2	T4-1	T4-2	T5-1	T5-2
+2½	100	100	100	100	100	100	100	100	100	100
2	100	96	99	100	100	97	100	100	100	100
1½	99	95	96	97	98	94	98	97	94	99
1	99	92	94	94	95	89	95	94	92	98
¾	98	89	92	92	94	86	88	91	91	97
½	97	84	83	90	92	81	78	83	89	96
⅜	95	79	84	87	90	76	72	76	87	93
No. 4	86	69	71	79	84	63	60	58	80	88
No. 8	71	54	57	64	69	51	47	40	66	83
No. 16	48	35	42	44	48	39	28	24	45	77
No. 30	27	19	28	26	26	26	13	13	27	67
No. 50	14	9	17	15	11	15	7	8	16	45
No. 100	8	5	11	12	6	8	4	5	11	23
No. 200	6	4	9	10	4	5	3	4	8	19

TABLE 4

FORT IRWIN
SACK GRADATION
SURVEY

CUMULATIVE PERCENT PASSING
COARSE AGGREGATE

<u>Sieve Size</u>	<u>T1-2</u>	<u>T2-1</u>	<u>T3-1</u>	<u>T4-2</u>	<u>T5-1</u>	<u>T6-1</u>	<u>T6-2</u>	<u>T7-1</u>	<u>T8-1</u>
+2½	100	100	100	100	100	100	100	100	100
+2	73	66	69	90	80	75	77	79	81
1½	57	58	59	78	71	67	65	72	67
1	47	48	50	67	62	59	54	65	57
¾	42	44	46	60	57	55	49	58	50
1/2	37	40	41	53	50	50	42	51	44
3/8	35	37	38	48	46	46	38	47	39
No. 4	30	31	32	38	38	39	30	37	32
No. 8	27	27	23	31	33	29	20	29	27
No. 16	24	22	14	24	26	20	14	21	21
No. 30	20	17	8	19	20	14	9	14	15
No. 50	16	13	5	13	15	9	6	10	10
No. 100	10	7	3	8	9	6	4	6	6
No. 200	5	4	1	4	3	3	2	3	3

TABLE 5

FORT IRWIN
SACK GRADATION
SURVEY

CUMULATIVE PERCENT PASSING
COARSE AGGREGATE

Sieve Size	T8-2	T9-1	T10-1	T11-1	T12-1	T17-1	T17-2	T20-1	T20-2
2½	100	100	100	100	100	100	100	100	100
+2	82	80	69	87	82	90	86	80	86
1½	67	69	57	81	72	81	77	67	78
1	55	60	47	73	62	73	68	56	68
¾	48	55	42	66	53	67	63	49	62
1/2	42	50	35	58	43	61	57	43	56
3/8	38	47	31	52	37	56	52	39	51
No. 4	32	42	26	40	29	46	43	30	42
No. 8	27	36	23	34	24	35	33	25	29
No. 16	22	30	21	23	19	25	23	19	20
No. 30	16	25	16	15	15	17	16	13	14
No. 50	12	20	11	10	11	12	11	10	10
No. 100	8	15	6	6	8	7	6	7	6
No. 200	4	7	3	3	3	2	3	3	3

FROM: CORPS OF ENGINEERS U. S. ARMY South Pacific DIVISION		REPORT OF SOUNDNESS TEST ASTM-C 88		ADDRESS: P. O. Box 37 Sausalito, CA 94966																	
SYMBOL		PROJECT FORT IRWIN		MATERIAL																	
SERIAL NO.		SOURCE Fine Aggragate Pit Run																			
COARSE AGGREGATE																					
SIEVE SIZE	GRADING FOR ORIGINAL SAMPLE (Per Cent)	WEIGHT OF TEST FRACTIONS BEFORE TEST (Grams)		WEIGHT OF TEST FRACTIONS AFTER TEST (Grams)		WEIGHT PASSING FINER SIEVE AFTER TEST ACTUAL LOSS (g)		% PASSING FINER SIEVE AFTER TEST ACTUAL % LOSS		WEIGHTED AVG CORRECTED PER CENT LOSS											
		RUN 1	RUN 2	RUN 1	RUN 2	RUN 1	RUN 2	RUN 1	RUN 2	RUN 1	RUN 2										
3/8" - #4																					
3/4-3/8"																					
1 1/2-3/4"																					
TOTALS																					
						SUM WEIGHTED AVG RUNS 1 & 2															
						AVG TOTAL WEIGHTED AVG RUNS 1 & 2		PER CENT													
CONSTITUENT (Size 1/2 to 1 in.)		NO. OF PARTICLES BEFORE TEST		NO. PARTICLES AFTER TEST																	
				SPLIT		CRUMBLED		CRACKED		FLAKED		SOUND		TOTAL							
				RUN 1	RUN 2	RUN 1	RUN 2	RUN 1	RUN 2	RUN 1	RUN 2	RUN 1	RUN 2	RUN 1	RUN 2						

FINE AGGREGATE									
SIEVE SIZE	GRADING FOR ORIGINAL SAMPLE (%)	WEIGHT OF TEST FRACTIONS BEFORE TEST (Grams)		WEIGHT OF TEST FRACTIONS AFTER TEST (Grams)		% PASSING FINER SIEVE AFTER TEST ACTUAL % LOSS		WEIGHTED AVERAGE CORRECTED % LOSS	
		RUN 1	RUN 2	RUN 1	RUN 2	RUN 1	RUN 2	RUN 1	RUN 2
3/8 in. - NO. 4									
NO. 4-8	18	100.0	100.0	70.0	71.0	30.0	29.0	5.4	5.2
NO. 8-16	25	100.0	100.0	74.0	73.0	26.0	27.0	6.5	6.8
NO. 16-30	22	100.0	100.0	83.0	84.0	17.0	16.0	3.7	3.5
NO. 30-50	16	100.0	100.0	91.0	90.0	9.0	10.0	1.5	1.6
NO. 50-100	13					0.0	0.0	0.0	0.0
NO. 100- PAN	6					0.0	0.0	0.0	0.0
TOTALS								17.1	17.1
						SUM WEIGHTED AVG RUNS 1 & 2		34.2	
						AVG TOTAL WEIGHTED AVG RUNS 1 & 2		17.1 PER CENT	

REMARKS		
COARSE BY	CHECKED	
FINE BY	DATE OF REPORT	
COMPUTED		

WES FORM
REV. DEC. 1955 477

FROM: CORPS OF ENGINEERS U. S. ARMY South Pacific DIVISION		REPORT OF SOUNDNESS TEST ASTM-C 88	ADDRESS: P. O. Box 37 Sausalito, CA 94966
SYMBOL	PROJECT Fort Irwin	MATERIAL	
SERIAL NO.	SOURCE Coarse Aggregate Pit Run		

COARSE AGGREGATE											
SIEVE SIZE	WEIGHTING FOR ORIGINAL SAMPLE (Per Cent)	WEIGHT OF TEST FRACTIONS BEFORE TEST (Grams)		WEIGHT OF TEST FRACTIONS AFTER TEST (Grams)		WEIGHT PASSING FINER SIEVE AFTER TEST ACTUAL LOSS (g)		% PASSING FINER SIEVE AFTER TEST ACTUAL % LOSS		WEIGHTED AVG CORRECTED PER CENT LOSS	
		RUN 1	RUN 2	RUN 1	RUN 2	RUN 1	RUN 2	RUN 1	RUN 2	RUN 1	RUN 2
3/8"-#4	2.5	300.0	300.0	280.0	273.0	20.0	27.0	6.6	9.0	1.7	2.3
3/4-3/8"	2.5	1000.0	1000.0	972.0	975.0	28.0	25.0	2.8	2.5	0.7	0.6
1 1/2-3/4"	5.0	1511.0	1505.0	1492.0	1485.0	19.0	20.0	1.3	1.3	0.6	0.6
TOTALS											
SUM WEIGHTED AVG RUNS 1 & 2										3.0	3.5
AVG TOTAL WEIGHTED AVG RUNS 1 & 2										3.3	PER CENT

CONSTITUENT (Size 1/2 to 1 in.)	NO. OF PARTICLES BEFORE TEST		NO. PARTICLES AFTER TEST												TOTAL	
			SPLIT		CRUMBOLED		CRACKED		FLAKED		SOUND					
	RUN 1	RUN 2	RUN 1	RUN 2	RUN 1	RUN 2	RUN 1	RUN 2	RUN 1	RUN 2	RUN 1	RUN 2	RUN 1	RUN 2		

FINE AGGREGATE									
SIEVE SIZE	GRADING FOR ORIGINAL SAMPLE (%)	WEIGHT OF TEST FRACTIONS BEFORE TEST (Grams)		WEIGHT OF TEST FRACTIONS AFTER TEST (Grams)		% PASSING FINER SIEVE AFTER TEST ACTUAL % LOSS		WEIGHTED AVERAGE CORRECTED % LOSS	
		RUN 1	RUN 2	RUN 1	RUN 2	RUN 1	RUN 2	RUN 1	RUN 2
3/4 IN. NO. 4	0								
NO. 4-8	17	100.0	100.0	87.0	88.0	13.0	12.0	2.2	2.0
NO. 8-16	22	100.0	100.0	90.0	88.0	10.0	12.0	2.2	2.6
NO. 16-30	22	100.0	100.0	90.0	89.0	10.0	11.0	2.2	2.4
NO. 30-50	17	100.0	100.0	86.0	95.0	86.0	14.0	2.4	0.9
NO. 50-100	16					0.0	0.0	0.0	0.0
NO. 100 PAN	6					0.0	0.0	0.0	0.0
TOTALS	100								
SUM WEIGHTED AVG RUNS 1 & 2								9.0	7.9
AVG TOTAL WEIGHTED AVG RUNS 1 & 2								8.5	PER CENT

REMARKS		
COARSE BY	CHECKED	
FINL BY	DATE OF REPORT	
COMPUTED		

WES FORM
REV. DEC. 1955 477

TABLE 6

FORT IRWIN

SUMMARY PETROGRAPHY

PIT RUN COARSE AGGREGATE

		<u>+2</u>	<u>1 1/2</u>	<u>1</u>	<u>3/4</u>	<u>1/2</u>	<u>3/8</u>	<u>4</u>	<u>No.</u> <u>8</u>	<u>No.</u> <u>16</u>	<u>No.</u> <u>30</u>	<u>No.</u> <u>50</u>	<u>No.</u> <u>100</u>
Granite	94	89	91	90	88	84	78	70	59	55	48	37	
Metagranite	6	7	4	5	5	2	2	-	-	-	-	-	
Andesite		1	3	3	2	7	6	3	1	2	1	-	
Quartz		3	2	2	3	4	7	14	26	28	36	46	
Feldspar					2	3	7	13	14	15	12	12	
Biorite											2	3	
Mafics											1	2	
Soft Particles			0.4			0.6							
Friable			0.1			0.2		3.4					

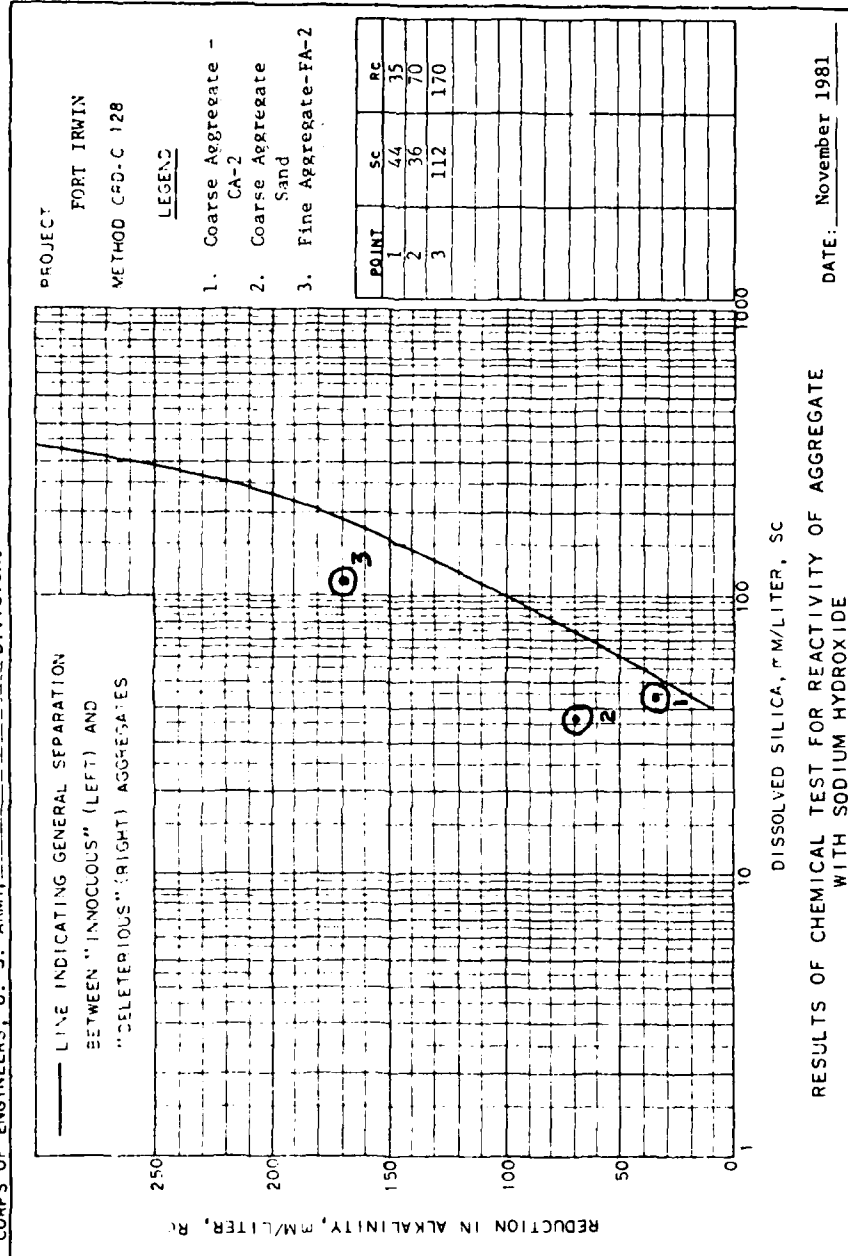
TABLE 7

FORT IRWIN

SUMMARY PETROGRAPHY

PIT RUN FINE AGGREGATE

	<u>1 1/2</u>	<u>1</u>	<u>3/4</u>	<u>1/2</u>	<u>3/8</u>	<u>4</u>	No. <u>8</u>	No. <u>16</u>	No. <u>30</u>	No. <u>50</u>	No. <u>100</u>
Andesite	47	46	48	44	42	36	34	30	27	23	18
Basalt	28	17	9	8	4	2	1	-	-	-	-
Rhyolite	17	10	10	9	10	12	15	11	8	4	-
Meta-igneous	8	21	12	13	12	14	10	8	2	-	-
Quartzite		6	9	11	10	12	12	15	20	17	14
Dacite			10	12	15	16	18	12	8	4	4
Tuff			2	2	3	2	1	-	-	-	-
Granite				1	4	5	4	1	-	-	-
Quartz						1	5	20	25	34	30
Feldspar								3	8	13	16
Mafics									2	5	9
Soft Particles		5.2			4.8						
Friable		0.4			0.4			1.3			



WES FORM
DEC. '55 896

TABLE 8

SUMMARY OF MIX DATA
CONCRETE MIX DESIGN

Coarse Aggregate Source: 33% Crushed
67% Pit Run

Fine Aggregate Source: Alluvial + 5.5 Crushed

Cement: Type I/II Kaiser Permanente

Max. Aggregate: 1½ inch

Mix No.	Actual CF	W/C lbs. CW	S/A % Vol.	Slump Inches	% Air	Compressive Strength Pounds Per Square Inch		
						1 Day	7 Days	28 Days
4	409	.69	45.5	3½	3.6	710	2100	3280
5	504	.56	41.5	3	3.9	1150	2785	3915
6	600	.47	37.5	3	4.0	1590	3800	5110

TABLE 9
SUMMARY OF MIX DATA
CONCRETE MIX DESIGN

Mix No.	Actual CF	W/C lbs. CF	S/A % Vol.	Slump Inches	% Air	Flexural Strength, psi			Compressive Strength, psi 28 Days
						14 Days	28 Days	90 Days	
1	459	.525	47.5	3/4	3.2	500	540		4750
2	557	.43	43.5	3/4	3.0	620	675		5750
3	651	.37	39.5	3/4	3.5	645	695		5980

Coarse Aggregate Source: 33% Crushed
67% Pit Run

Cement: Type I/II Kaiser Permanente

Max. Aggregate: 1 1/4 inch

REPORT OF SELECTION OF CONCRETE MIXTURE PROPORTIONS (CIRC. C-3)

PROJECT NAME

DATE

CONCRETE REQUIRED FOR **Fort Irwin**

MIXTURE NO. **1**

PORTLAND CEMENT
TYPE **I / II**
BRAND & MFG **Kaiser**

POSITION
TYPE
SOURCE

MATERIALS
AIR ENT. ADMIXTURE
TYPE **Lab Standard**
AMOUNT

TYPE *	FINE AGGREGATE	TYPE	COARSE AGGREGATE
SOURCE		SOURCE	

MATERIALS	SIZE RANGE	% COARSE	BULK SP GR	ABSORPTION
PORTLAND CEMENT	XXXXXX	XXXXXX		XXXXXX
POSITION	0 % REPLACEMENT	XXXXXX	0	
FINE AGGREGATE		XXXXXX	2.47	4.2
COARSE AGGREGATE A	Crushed oversize	33	2.55	1.9
COARSE AGGREGATE B	No. 4 x 1 1/2	67	2.66	1.1
COARSE AGGREGATE C		0	0	
COARSE AGGREGATE D		0	0	
COARSE AGGREGATE E		0	0	

MIXTURE DATA		
	WGT. (LB.)	VOL. (CU. FT.)
CEMENT	459	2.342
COARSE AGG.	0	0
FINE AGG.	1409	9.358
COARSE AGG. A	552	3.455
COARSE AGG. B	1163	7.011
COARSE AGG. C	0	0
COARSE AGG. D	0	0
COARSE AGG. E	0	0
WATER	241	3.062
AIR	XXXXXX	.064
TOTAL	2475	27
W/C RATIO	.525	SLUMP (INCHES) 47.5
SLUMP (INCHES)	.75	ACTUAL UNIT WT (LB./CU. FT.) 143.5
PER CENT AIR	3.2	ADJUSTED CEMENT FACT. (LB./CU. FT.) 459

SPECIMEN DATA			BEAMS (38" x 6" x 6") 2 breaks per beam		
DATE	AGE	WGT	DATE	AGE	PSI
5	28	4750	5	14	500
			5	28	540

* Sand consists of alluvial sand plus 5.5% crusher sand.

REPORT OF SELECTION OF CONCRETE MIXTURE PROPORTIONS (CRP-13)

PROJECT NAME

Date

CONCRETE REQUIRED FOR **Ft. Irwin**

MIXTURE No. **2**

PORTLAND CEMENT
TYPE I/II
BRAND & MILL **Kaiser**

POZZOLON
TYPE
SOURCE

MATERIALS
AIR ENT. ADMIXTURE
TYPE **Lab Standard**
AMOUNT

FINE AGGREGATE		COARSE AGGREGATE	
TYPE	SOURCE	TYPE	SOURCE

MATERIALS	SIZE RANGE	% COARSE	BULK SP GR	ABSORPTION
PORTLAND CEMENT	XXXXXX	XXXXXX		XXXXXX
POZZOLON	0 % REPLACEMENT	XXXXXX	.0	
FINE AGGREGATE		XXXXXX	2.47	4.2
COARSE AGGREGATE A	Crushed oversize	33	2.56	1.0
COARSE AGGREGATE B	No. 4 x 1½	47	2.66	1.1
COARSE AGGREGATE C		0	0	
COARSE AGGREGATE D		0	0	
COARSE AGGREGATE E		0	0	

MIXTURE DATA		
	WT./CU. YD.	VOL./YD. (CU. FT.)
CEMENT	557	2.947
POZZOLON	0	0
FINE AGG.	1308	3.497
COARSE AGG. A	581	3.639
COARSE AGG. B	1171	2.385
COARSE AGG. C	0	0
COARSE AGG. D	0	0
COARSE AGG. E	0	0
WATER	230.5	3.803
AIR	XXXXXX	.81
TOTAL	3911.5	27

W/C (WT)	.43	S/A, 1 VOLUME	43.5
SLUMP (IN.)	75	ACTION UNIT WT (LB/CU FT)	144.9
AIR CONTENT %	3	ACTION CEMENT FACT. (LB/CU FT)	557

CYLINDERS			SPECMEN DATA			BEAMS (36" x 6" x 6") 2 breaks per beam		
SIZE No.	AGE	PSI	SIZE No.	AGE	PSI	SIZE No.	AGE	PSI
5	28	5750	5	14	620	5	14	620
			5	28	675			

* Sand consists of alluvial sand plus 5.5% crusher sand

REPORT OF COLLECTION OF CONCRETE MIXTURE PROPORTIONS
(CFC-103)

PROJECT NAME

DATE

CONCRETE REQUIRED FOR

Port Irwin

MIXTURE No. 3

PORTLAND CEMENT

POZZOLON

MATERIALS

TYPE I/II

TYPE

AIR ENT. ADMIXTURE

BRAND & MFG. Kaiser

SOURCE

TYPE Lab Standard

AMOUNT

* FINE AGGREGATE

COARSE AGGREGATE

TYPE

TYPE

SOURCE

SOURCE

MATERIALS	SIZE RANGE	% COARSE	BULK SP GR	ABSORPTION
PORTLAND CEMENT	XXXXXX	XXXXXXX		XXXXXXX
POZZOLON	0 % REPLACEMENT	XXXXXXX	0	
FINE AGGREGATE		XXXXXXX	2.47	4.2
COARSE AGGREGATE A	Crushed oversize	33	2.56	1.9
COARSE AGGREGATE B	No. 4 x 1 1/2	67	2.66	1.1
COARSE AGGREGATE C		0	0	
COARSE AGGREGATE D		0	0	
COARSE AGGREGATE E		0	0	

MIXTURE DATA

	POZZOL. VOL.	VOL./YD. (CU. FT.)
CEMENT	651	3.32
POZZOLON	0	0
FINE AGG.	1149	7.455
COARSE AGG. A	601	3.762
COARSE AGG. B	1070	7.65
COARSE AGG. C	0	0
COARSE AGG. D	0	0
COARSE AGG. E	0	0
WATER	240.9	3.861
AIR	XXXXXX	.945
TOTAL	3912.9	27
W. (CU. FT.)	37	0.26 % VOLUME
WATER (CU. FT.)	.75	ACTUAL UNIT WT. (LB/CU FT.)
AIR (PERCENT %)	3.5	ACTUAL CEMENT FACT. (LB/CU FT.) 351

SPECIMEN DATA

CYLINDERS			BEAMS		
SIZE	AGE	PSI	SIZE	AGE	PSI
No.			No.		
			5	14	645
			5	28	695

* Sand consists of alluvial sand plus 5.5% crusher sand.

REPORT OF SELECTION OF CONCRETE MIXTURE PROPORTIONS
(CRC-C 3)

PROJECT NAME

DATE

CONCRETE REQUIRED FOR **FT. IRWIN**

MIXTURE No. **4**

PORTLAND CEMENT
TYPE **I/II**
BRAND & MILL **Kaiser**

POZZOLON
TYPE
SOURCE

MATERIALS
AIR ENT. ADMIXTURE
TYPE **Lab Standard**
AMOUNT

TYPE *
SOURCE
FINE AGGREGATE

TYPE
SOURCE
COARSE AGGREGATE

MATERIALS	SIZE RANGE	% COARSE	BULK SF GR	ABSORPTION
PORTLAND CEMENT	XXXXXXX	XXXXXXX		XXXXXXX
POZZOLON	0 % REPLACEMENT	XXXXXXX	0	
FINE AGGREGATE		XXXXXXX	2.47	4.2
COARSE AGGREGATE A	Crushed oversize	33	2.56	1.9
COARSE AGGREGATE B	No. 4 x 1½	67	2.66	1.1
COARSE AGGREGATE C		0	0	
COARSE AGGREGATE D		0	0	
COARSE AGGREGATE E		0	0	

MIXTURE DATA		
	WT./CU. YD.	VOL./YD. (CU. FT.)
CEMENT	409	2.087
POZZOLON	0	0
FINE AGG.	1361	8.836
COARSE AGG. A	518	3.492
COARSE AGG. B	1177	7.091
COARSE AGG. C	0	0
COARSE AGG. D	0	0
COARSE AGG. E	0	0
WATER	282.2	4.522
AIR	XXXXXXX	.972
TOTAL	3797.2	27

WATER (WT)	.67	S/A, % VOLUME	45.5
WATER (CN)	3.25	ACTUAL UNIT WT (LB/CU FT)	140.3
AIR (WT) %	3.6	ACTUAL CEMENT FACT. (LB/CU FT)	409

CYLINDERS			BEAMS		
SIZE	AGE	PSI	SIZE	AGE	PSI
No. 3	1	710			
5	7	2100			
5	28	3280			

* Sand consists of alluvial sand plus 5.5% crusher sand.

REPORT OF SELECTION OF CONCRETE MIXTURE PROPORTIONS (FORM 13)

PROJECT NAME

DATE

CONCRETE REQUIREMENT **FT. IRWIN**

MIXTURE No. **5**

PORTLAND CEMENT

POZZOLAN

GASTRIALS

TYPE **I/II**

TYPE

AIR ENT. ADMIXTURE

BRAND NAME **Kaiser**

SOURCE

TYPE **Lab Standard**
AMOUNT

FINE AGGREGATE

COARSE AGGREGATE

TYPE *

TYPE

SOURCE

SOURCE

MATERIALS	SIZE RANGE	% COARSE	BULK SP GR	ABSORPTION
PORTLAND CEMENT	XXXXXX	XXXXXXX		XXXXXXX
POZZOLON	0.075 RETAINMENT	XXXXXXX	0	
FINE AGGREGATE		XXXXXXX	2.47	4.2
COARSE AGGREGATE	5 Crushed oversize	33	2.56	1.9
COARSE AGGREGATE	No. 4 x 1 1/2	67	2.66	1.1
COARSE AGGREGATE		0	0	
COARSE AGGREGATE		0	0	
COARSE AGGREGATE		0	0	

MIXTURE DATA			VOLUME (CU. FT.)	
	WET WT. (LB.)			
CEMENT	504		2.571	
POZZOLON	0		0	
FINE AGG.	1005		7.821	
COARSE AGG. 1	501		3.64	
COARSE AGG. 2	1022		7.39	
COARSE AGG. 3	0		0	
COARSE AGG. 4	0		0	
COARSE AGG. 5	0		0	
WATER	282.5		4.522	
AIR	XXXXX		1.053	
TOTAL	2822.5		27	
WATER/CEMENT	.53		WATER % VOLUME	41.5
WATER/POZZ.			ACTUAL BULK WT. (LB/CU FT.)	140.7
WATER/AGG. 1	3.8		ACTUAL CEMENT FACT. (LB/CU FT.)	504

SPECIMEN DATA			BEANS		
SIZE	AGE	PSI	SIZE	AGE	PSI
3	1	1150			
5	7	2785			
5	28	3915			

* Sand consists of alluvial sand plus 5.5% crusher sand.

RESEARCH ON EFFECTS OF CONCRETE MIXTURE PROPORTIONS

[illegible]

111

RECEIVED 11 JUL 1964 FT. IRWIN

MAY JUNE No. 6

FOUR AND ONE
YEAR I/II
COST \$ 1114

1977
 1978
 1979

REMARKS
 CAR 100 - ADMIXTURE
 100 Lab Standard
 000000

1977 ★ *THE GARDEN OF EDEN*
 500 PAGES

SOURCE

MATERIALS	SIEVE RANGE	% COARSE	TOTAL #P GR	ABSORPTION
PORTLAND CEMENT	XXXXXX	XXXXXX		XXXXXXX
POZZOLON	100% REPLACEMENT	XXXXXX	0	
FINE AGGREGATE		XXXXXX	2.47	4.2
COARSE AGGREGATE	Crushed oversize	85	2.56	1.9
COARSE AGGREGATE	No. 4 x 1 1/2	15	2.66	1.1
COARSE AGGREGATE		0	0	
COARSE AGGREGATE		0	0	
COARSE AGGREGATE		0	0	

MEETING OF THE

Chemical	$\log K_{\text{eq}}$	$\log K_{\text{eq}}^{\text{calc}}$
H_2O	8.00	7.974
H^+	0	0
OH^-	-14.00	-14.026
H_2CO_3	6.35	6.33
HCO_3^-	10.33	10.30
CO_3^{2-}	16.75	16.72
H_2SiO_3	6.35	6.33
H_2SiO_4	10.33	10.30
H_2SiO_5	16.75	16.72
H_2SiO_6	23.17	23.14
H_2SiO_7	29.59	29.56
H_2SiO_8	36.01	35.98

2000000	130	2000000	37.5
1000000	3	1000000	141.5
1000000	4	1000000	500

REFERENCES

DEBITORS			CREDITORS		
STATE	DATE	AMOUNT	STATE	DATE	AMOUNT
3	1	1590			
5	7	3800			
5	28	5110			

* Sand consists of alluvial sand plus 5.5% crusher sand.

TABLE 10

SUMMARY OF ASPHALT CONCRETE DATA

	<u>AR 8000</u>	<u>AR 4000</u>	<u>Spec. Limit (a)</u>	<u>AR 8000</u>	<u>AR 4000</u>	<u>Spec. Limit (b)</u>
Design Value	5.4			5.2		
% Total Voids	78	78	75-85	74	83	70-80
% Voids Filled	3.9	3.0	3-5	4.2	2.4	3-5
Stability (lbs)	2740	2490	500	3320	3880	1800
Flow (1/100 in.)	13	11	(Max) 20	12	10	(Max) ¹⁶ 20
% Retained Stability	55	70	75 (c)	45	85	75 (c)

(a) CE-807.22 Table 5 (Pressure below 100 psi)

(b) CE-807.22 Table 5 (Pressure above 100 psi)

(c) CE-807.22 Para. 5.2.2

Design values based on mix design studies for AR 8000

Asphalt - Husky from Hunt Mix Asphalt of Upland, California

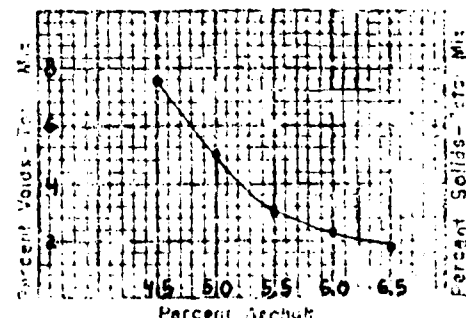
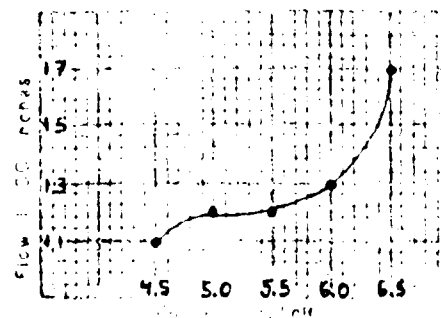
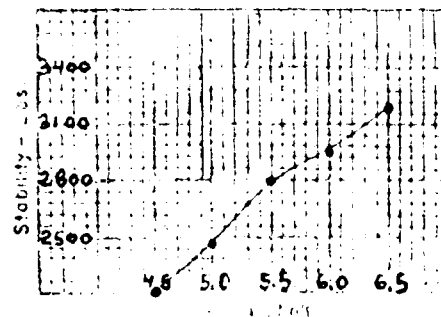
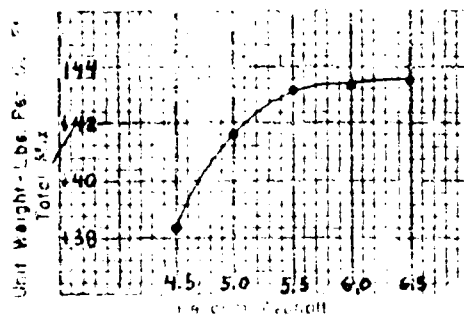
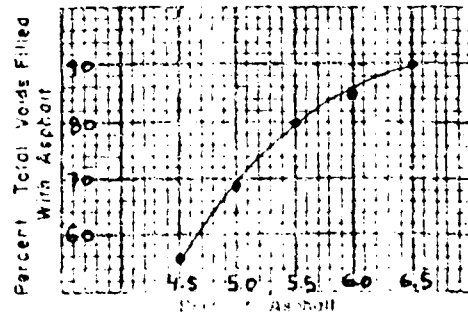
Aggregate - Gradation from CE-807.22 composed of crushed coarse aggregate with crusher fines and sand from the coarse aggregate.

The graph illustrates the relationship between Percent Passing and Screen Number for two different aggregate gradations. The Y-axis represents Percent Passing (0 to 100), and the X-axis represents Screen Number (3 to 200). Two curves are shown: a solid line and a dashed line, both with data points plotted. The solid line represents a finer gradation, while the dashed line represents a coarser gradation.

Screen Number	Percent Passing (Solid Line)	Percent Passing (Dashed Line)
3	75	75
4	80	78
5	85	80
10	90	85
20	95	90
30	98	95
40	99	98
60	100	100
80	100	100
100	100	100
200	100	100

FORT IRWIN

A29



MIX DESIGN DATA		DISTRICT	
50 Blow		FORT IRVIN	
500 lb.		AGGREGATE SOURCE	
AR-8000		TESTER	
		COMPARISON	
		DESIGNED	
DESIGN AND CONTROL OF ASPHALT PAVING MIXTURES			
SOUTH PACIFIC PORTLAND CEMENT CO.			
SAN FRANCISCO, CALIFORNIA			

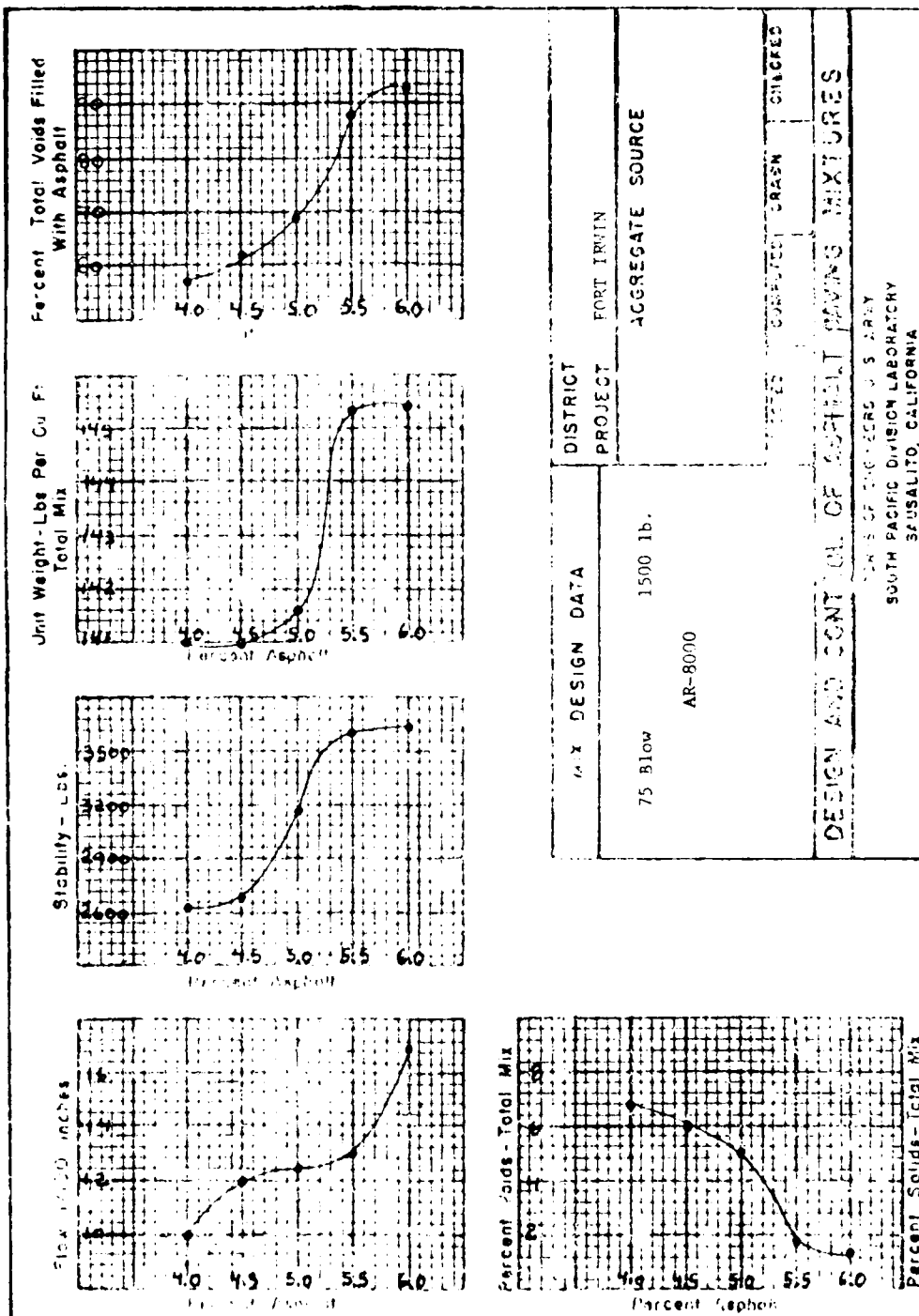


PLATE 1

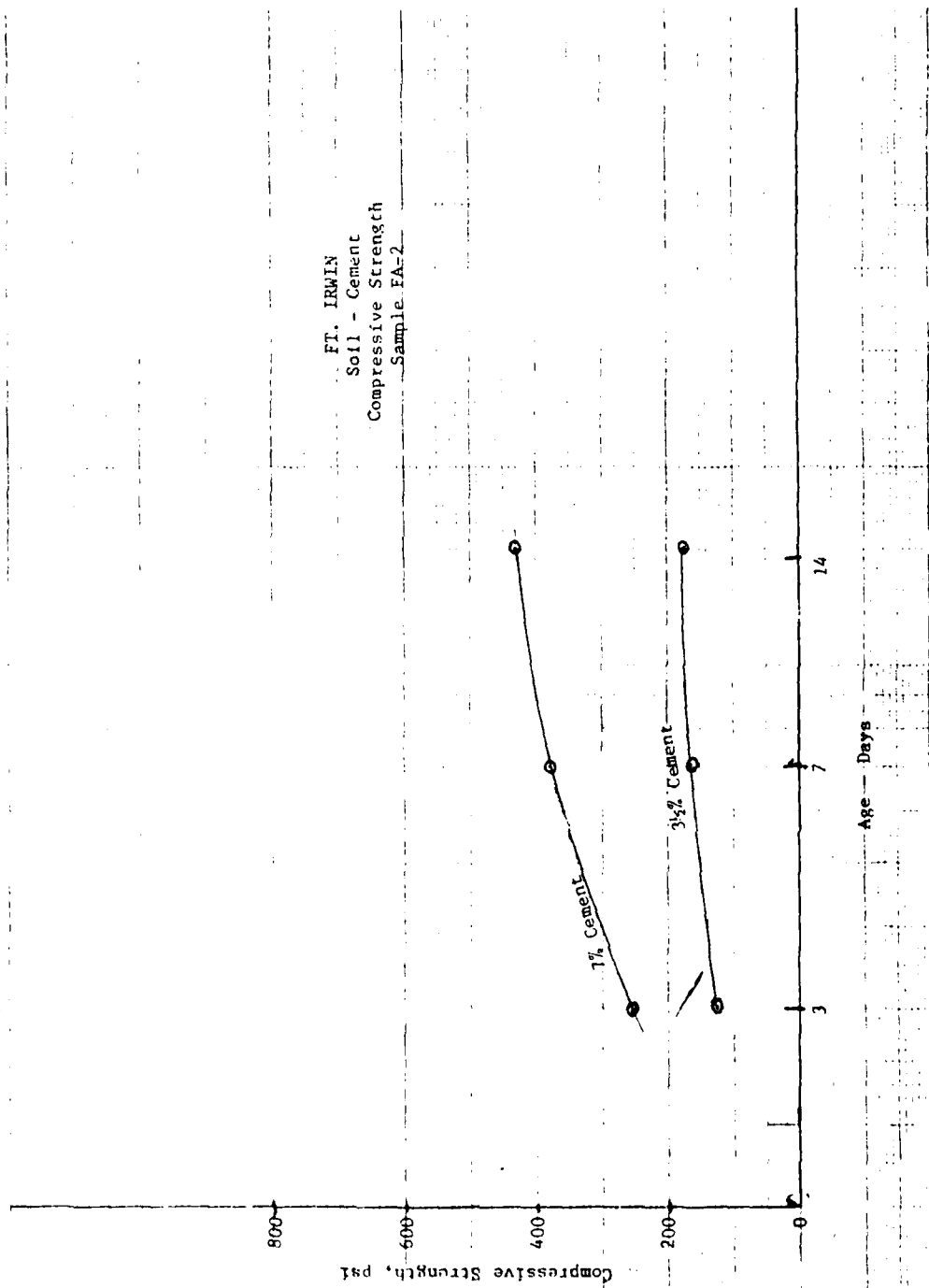
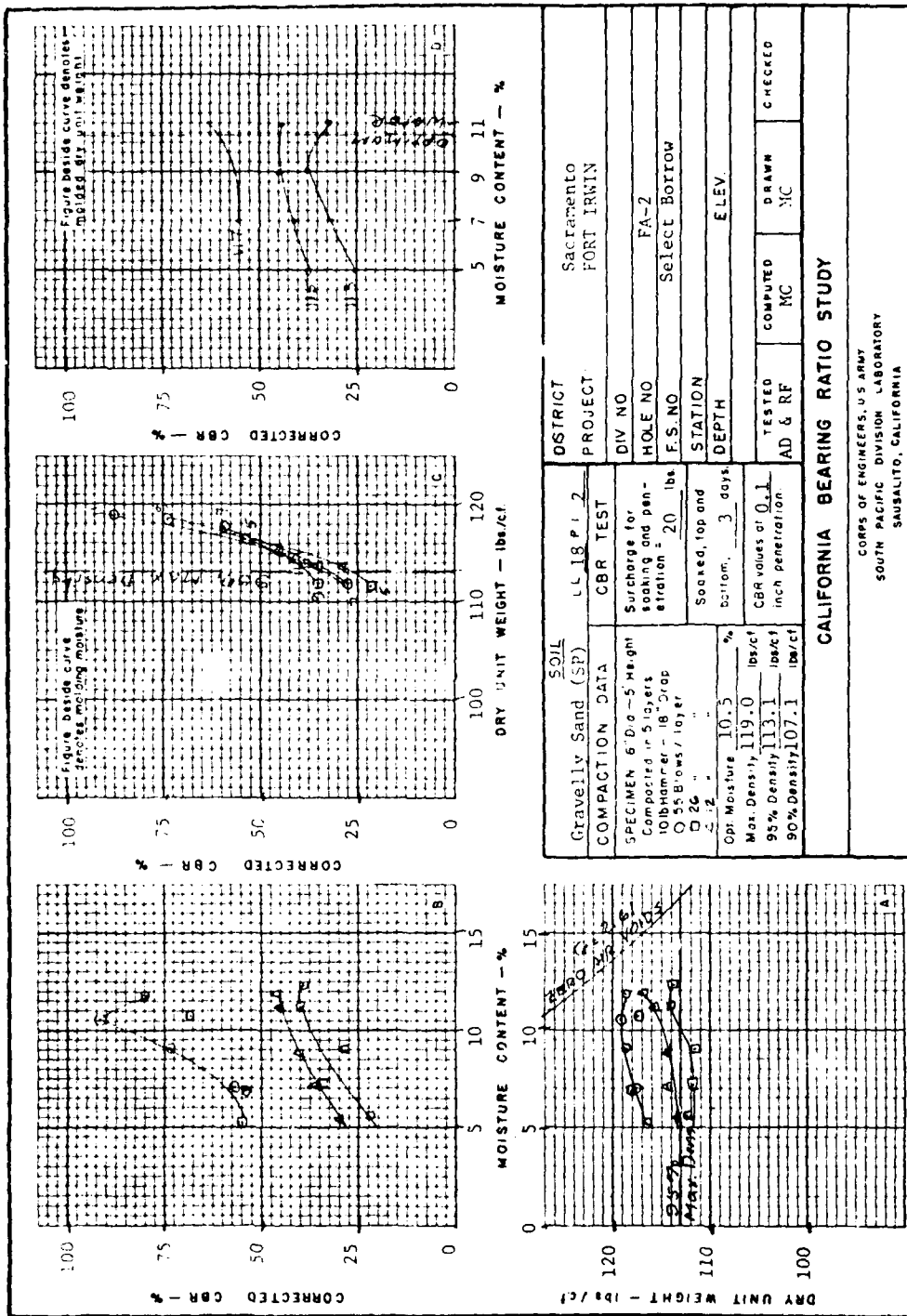


TABLE 11

FORT IRWIN

SOIL-CEMENT
Sample FA-2

Cement Content, %		Molding		Age Days	Compressive Strength psi
by Weight	by Volume	Water %	Density psi		
3.5	4.1	8.9	115.1	3	123
"	4.1	8.9	115.1	"	124
3.5	4.1	9.3	114.7	7	159
"	4.1	9.3	114.7	"	167
3.5	4.1	9.2	114.8	14	171
"	4.1	9.1	114.9	"	172
7.0	8.1	8.4	115.7	3	271
"	8.1	8.2	115.9	"	242
7.0	8.0	8.7	115.3	7	389
"	8.1	8.3	115.8	"	-
7.0	8.0	8.5	115.6	14	403
"	8.0	8.7	115.3	"	459



Gravelly Sand (SP)		DISTRICT		Sacramento	
COMPACTION DATA		PROJECT		FORT IRWIN	
SPECIMEN 6" Dia - 5 height		DIV NO			
Compacted in 5 layers		HOLE NO		FA-2	
10lb hammer - 18" drop		F.S. NO		Select Borrow	
O 55 Blows / layer		STATION			
O 26 " "		DEPTH		ELEV.	
Opt Moisture 10.5 %		TESTED		COMPUTED	
Max Density 119.0 lb/cf		AD & RF		MC	
95% Density 113.1 lb/cf		DRAWN		MC	
90% Density 107.1 lb/cf		CHECKED			
CALIFORNIA BEARING RATIO STUDY					
CORPS OF ENGINEERS, U.S. ARMY SOUTH PACIFIC DIVISION LABORATORY SAUSALITO, CALIFORNIA					

PLATE

SPD FORM 97 (Civil) (Replaces PSD 97 Civil) which may be used

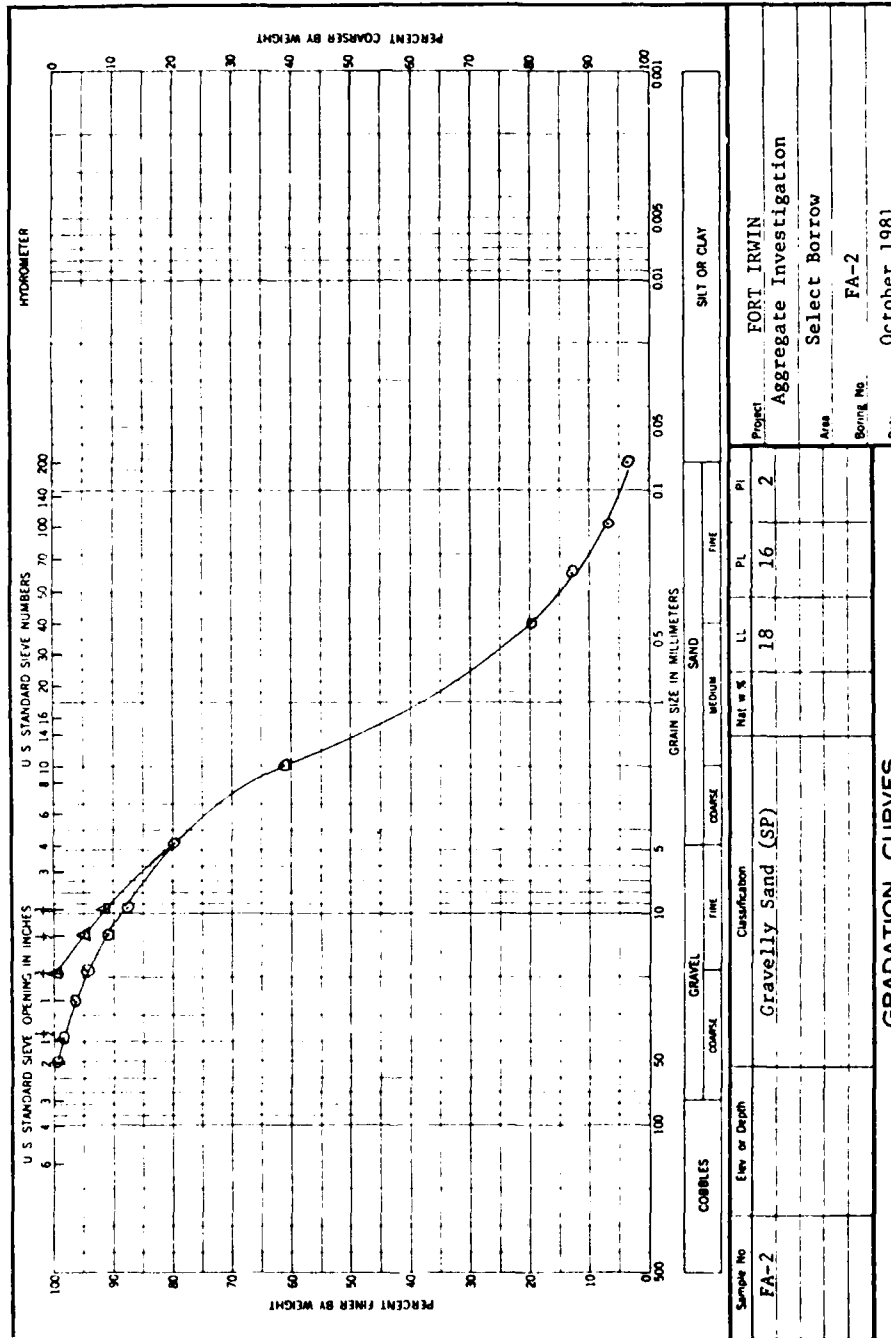
5 OCT 51

CALIFORNIA BEARING RATIO TEST - SUMMARY

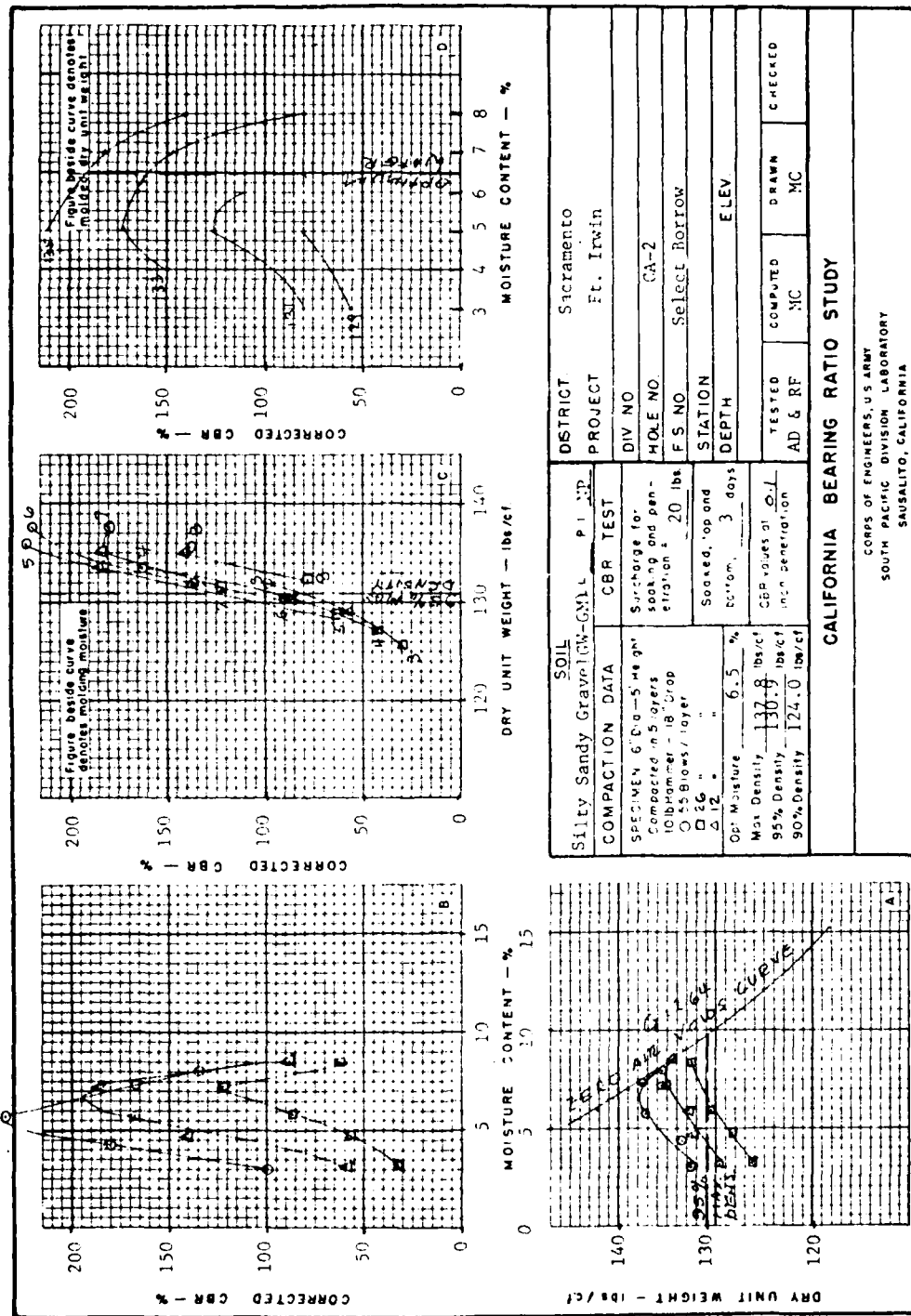
SPD FORM 165
OCT 74

EDITION OF 8 OCT 51 WILL BE USED UNTIL EXHAUSTED.

A35

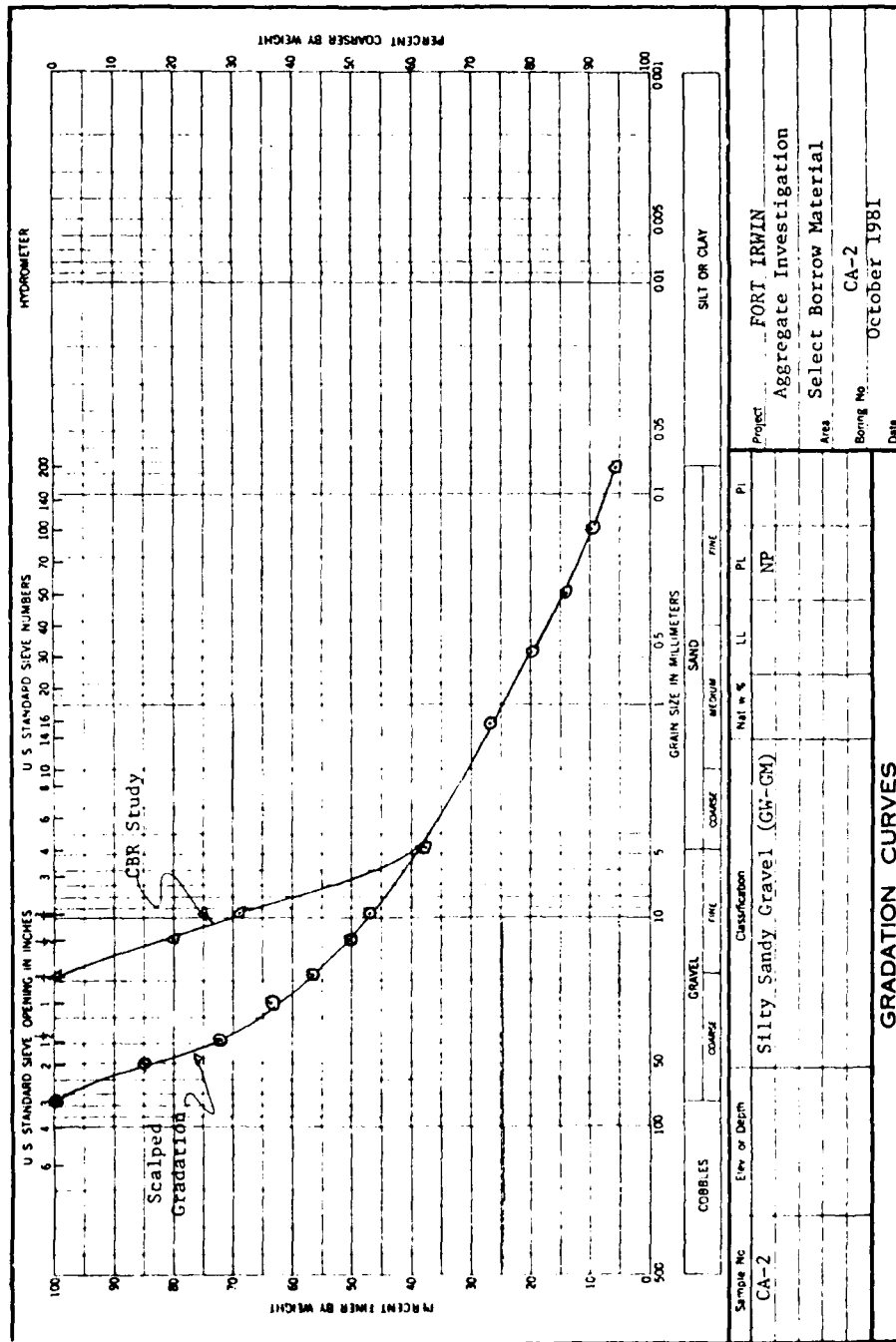


ENG FORM 2087
1 MAY 83

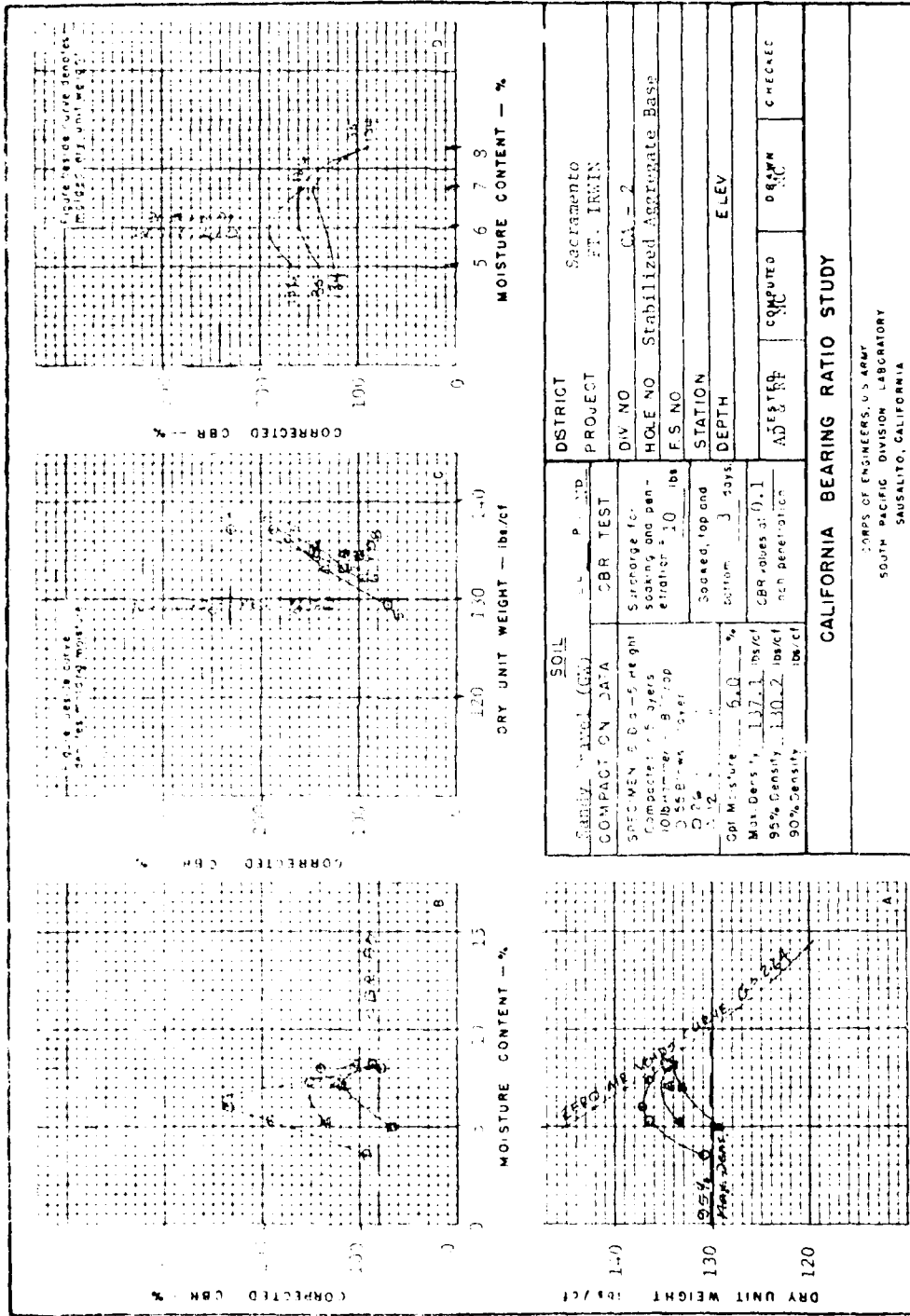


PLATE

SPD FORM 97 (Rev. 11) (Replaces PSD 97 Civil which may be used)



ENG FORM
MAY 83 2087



PLATE

SOIL		DISTRICT	
SANDY SILT (CL)		Sacramento	
COMPACT ON DATA		PROJECT	
SPECIMEN 5 0.5-5 wet gm		FT. IRWIN	
Compacted 1.5 layers		DIV NO	
100mm x 100mm x 100mm		CA - 2	
3.55 lb x 3.55 lb x 3.55 lb		HOLE NO	
0.25 lb x 0.25 lb x 0.25 lb		Stabilized Aggregate Base	
0.25 lb x 0.25 lb x 0.25 lb		F.S. NO	
0.25 lb x 0.25 lb x 0.25 lb		STATION	
0.25 lb x 0.25 lb x 0.25 lb		DEPTH	
0.25 lb x 0.25 lb x 0.25 lb		ELEV	
0.25 lb x 0.25 lb x 0.25 lb		AD & NB	
0.25 lb x 0.25 lb x 0.25 lb		COMPUTED	
0.25 lb x 0.25 lb x 0.25 lb		CHECKED	
CALIFORNIA BEARING RATIO STUDY			
CORPS OF ENGINEERS, U.S. ARMY			
SOUTH PACIFIC DIVISION, LABORATORY			
SAUSALITO, CALIFORNIA			

SPD form 97 (Civil) (Replaces PSD 97 Civil which may be used)

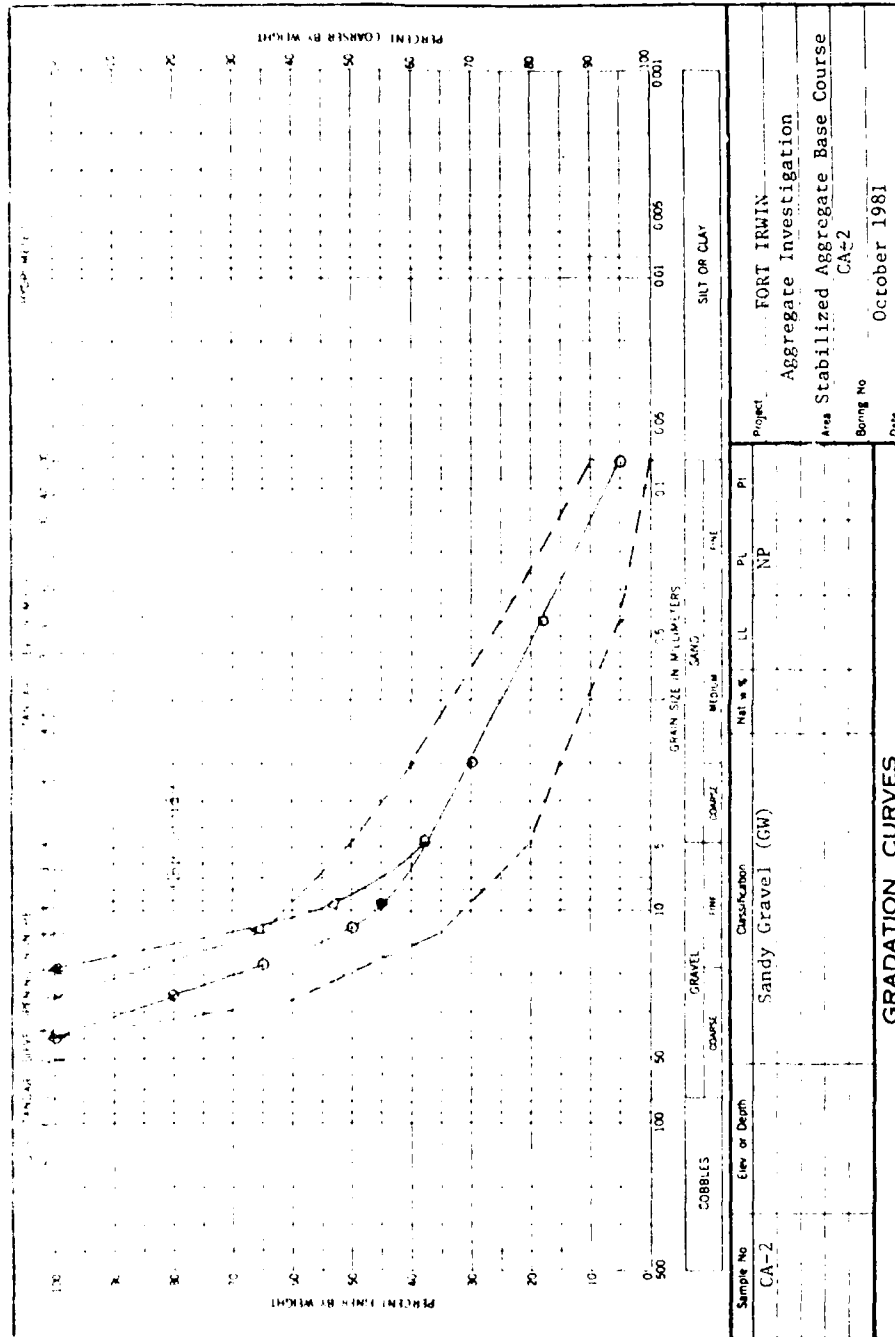
5 OCT 51

CALIFORNIA BEARING RATIO TEST - SUMMARY

SPD FORM 165
1 OCT 74

EDITION OF 8 OCT 51 WILL BE USED UNTIL EXHAUSTED.

A41



ENG FORM 2087
1 MAY 63

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Webster, Steve L.

Engineering and geologic investigation of potential sources of aggregate, Fort Irwin, California / by Steve L. Webster, Lawson M. Smith (Geotechnical Laboratory, U.S. Army Engineer Waterways Experiment Station). -- Vicksburg, Miss. : The Station ; Springfield, Va. ; available from NTIS, 1982.

75 p. in various pagings : ill. ; 27 cm. -- (Miscellaneous paper ; GL-82-9)

Cover title.

Final report.

"Prepared for U.S. Army Engineer District, Sacramento."

Bibliography: p. 30-31.

1. Aggregates (Building materials). 2. Building materials. 3. Geology. 4. Ft. Irwin (Calif.)
I. Smith, Lawson M. II. United States. Army. Corps

Webster, Steve L.

Engineering and geologic investigation of potential : ... 1982.
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of Engineers. Sacramento District. III. U.S. Army Engineer Waterways Experiment Station. Geotechnical Laboratory. IV. Title V. Series: Miscellaneous paper (U.S. Army Engineer Waterways Experiment Station) ; GL-82-9.

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